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MARCH 1960

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A Journal for All Science and Mathematics Teachers

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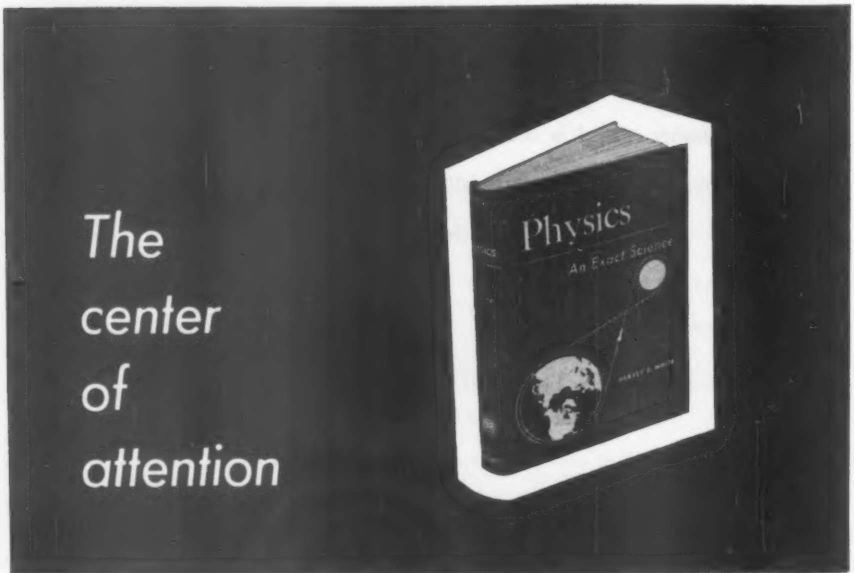

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SCHOOL SCIENCE AND MATHEMATICS

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On Physics for the First Grade*

Raymond J. Seeger

National Science Foundation, Washington 25, D. C.

A few years ago I read an article[1] which Linus Pauling had written for UNESCO on "The Significance of Chemistry." He proposed a "program for the education of the citizen in science, which would start at the kindergarten level." In analogy with mathematics training he argued that, if we wish our young people to be prepared adequately in science, we must begin their instruction in it as early as possible. Chemistry for the kindergarten! Why not, then, physics for the first grade? With this as a slogan I highly recommend the teaching of science to children at all levels of elementary education. Together with Pauling I would suggest such a program not merely for academically talented students, but also for normally growing youngsters—indeed, above all, for young citizens of average intelligence.

Some of you may have read an article[2] by Mary Mitchell about an experiment in teaching physical science to pupils in kindergarten and grades 1–3 at Beauvoir, the elementary school of the National Protestant Cathedral in Washington, D. C. In the fall of 1956 the principal of Beauvoir asked me to talk to its faculty about integrating science and arithmetic[3] in grades 1, 2, and 3. This primary school problem was one I had only casually considered as a learning parent,

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* Based upon a talk given at the annual meeting of the AAPT in New York Jan. 1959. This article was also published in the *American Journal of Physics, XXVII* (October, 1959) 494–500.

[1] L. Pauling, "The Significance of Chemistry," *Engineering and Science Monthly* of the California Institute of Technology (Jan. 1951).

[2] M. Mitchell, "Children Are Smarter Than You Think," *Saturday Evening Post*, 28 (9 Mar., 1957).

[3] R. J. Seeger, "Mathematical Science and the Manpower Problem," *The Mathematics Teacher*, 50: 10 (1957); "Teaching the Three A's in Elementary Mathematics," *The Arithmetic Teacher*, 4: 24 (1957).

but it soon grew increasingly important, interesting, and challenging to me. After all, a child's natural environment is not so much biological necessity or even social interest, it is really the toyland of physics, which soon transforms into physics sportland. Why should we not invite children to regard their "funful" experiences from a scientific point of view? Why not encourage them early to observe carefully, to measure approximately, and to think imaginatively! As I continued thinking[4] about the whole matter, it occurred to me that certain phenomena of light such as its rectilinear propagation, its refraction, and its reflection, might well be presented to children in the first grade; that some understanding of machines (mechanical advantage, speed ratio) might be feasible in the second grade; and that certain physical properties such as density (bodies of same size and of same weight), pressure (ocean depth and surface floating), temperature, and inertia (frictional effects) might be introduced in the third grade. I proposed that pupils at this level should become familiar also with gravitational phenomena, say, the weight of an apple and of the moon, the motion of a falling stone and of a waterfall, the stability of a standing boy and of a walking dog. I had no justification at all for selecting these particular subjects for those grades except the experiences of a humble teacher endeavoring to communicate to college freshmen some of his own enthusiastic interest in physics. In this connection I have always been impressed with the facts which my own boy knew at the age of seven, but which I myself had not met until much later. Dare I confess—as a mathematical physicist—that I never actually confronted transformers on intimate terms until my own college course in physics? My son, however, has been using them ever since he was six years of age. Furthermore, it has always seemed to me somewhat incongruous—if not ludicrous—to have husky football players pulling small weights on fine strings over miniature pulleys. How much more meaningful to have a boy try lifting a heavy load directly and then do it easily by means of pulleys! What is the appropriate psychological, social, and intellectual age for learning about machines?

It so happened about this same time that I gave some talks to fourth grade pupils at the National Cathedral School for Girls and at the Sidwell Friends School. One was entitled "Journey into Outer Space."[5] We started with our nearest neighbor and then the nearest

[4] M. Faraday, "The Chemical History of a Candle," (London, 1960–61).
W. S. Franklin, "Bill's School and Mine," (Bethlehem, 1913).
W. Payne, "Rousseau's Émile," (New York, 1911).
J. Trowbridge, "Philip's Experiments," (New York, 1898).
W. R. Whitney, "Things I've Been Thinking About," *American Magazine of General Electric Co.* (Oct., 1937).

[5] R. S. Ball, "Starland," (London, 1887–88).
J. H. Jeans, "The Stars in Their Courses," (London, 1936); "Through Space and Time" (London, 1945).
H. H. Turner, "A Voyage in Space," (London, 1913).

star; on an earthbeam we tranversed our planet family and then our star family; finally we became lost in wonder amid the galaxies themselves. The other talk, entitled "Apples and Moons," began with the cave man's attitude toward nature. Fearing the rolling stone, the restless river, and the raging wind, he ran away to hide from these living things. He was awe-struck by unpredictable eclipses, by falling stars, by tail-bearing comets. Then came ancient man. Stopping to look around his curious panorama, he wondered about the moving-picture book in the sky with its evercircling moon; he pondered about the reason why an apple falls and smoke rises. He was inspired to search for relations among events; to comprehend nature itself.[6] A few brave minds dared to measure the distance to the moon and the distance around the earth. (In class a couple of children, marooned on a table with a stick, determined the distance to a ceiling light.) Modern man became fascinated by simpler questions like the what and how of everyday things. In so doing he discovered the universe with its one law for apples and for moons; in describing phenomena he found that he himself could predict them. Then he copied nature; in imitation of the falling moon he ejected a revolving satellite into space. These lectures, "adapted to a juvenile auditory," convinced me that scientific matters can be presented to youngsters in an informative and interesting manner. In a strict sense, however, I would be the first to admit that as teaching they were necessarily incomplete, possibly somewhat superficial; they did not plumb the depth of understanding. I was always conscious of a theatrical artificiality like that of the professor who used to startle his beginning class with an electromagnetic bang to illustrate a physical change and then with an explosive boom for a chemical change. The class undoubtedly kept its eyes open. But what did it see? After all, what we see in things depends upon our thinking about them as much as upon our looking at them.

My first genuine experience in teaching elementary grades began a short time later when my daughter came home and said, "Daddy, can't you do anything?" I waited. She told of a little girl in her class whose father had given a talk about his trip to Athens (the girl had received extra credit). "Daddy, can't you do anything?" I found myself agreeing to talk to the fifth grade girls on some scientific subject. But what? I had just been reading James Gray's 1951 Christmas Lectures[7] at the Royal Institution. He discussed walking and running, jumping and creeping, high heels and canes and kangaroos. The basic physical concept was the center of gravity. How about this for a topic? Afterwards, I rationalized my choice when I recalled

[6] F. S. Taylor, "An Illustrated History of Science," (London, 1955).

[7] J. Gray, "How Animals Move," (Cambridge, 1953).

that this very concept had truly been the first one created in physics —by Archimedes. "Ontogeny recapitulates phylogeny"—intellectually.

I ventured to talk about "Sticks and Stones"—with a number of objects from home, as well as some common demonstration materials. (The class was encouraged to write a diary note that night on "Sticks and Stones I saw on my way home—and what I thought about them.") I began by chatting about ordinary stones and a few unusual ones I happened to have with me, such as a piece of amber, a piece of magnetite, a meteorite, and, believe it or not, one of my personal gallstones. You might be interested in an outline of my planned attack. I began with the concept itself, that remarkable point (sometimes invisible and even imaginary) which everybody has. We examined a uniform yardstick and a tapered pointer. We used a stone on the end of string to determine the center of gravity of a swinging board. Each pupil took home an irregular piece of cardboard for her own experimentation on its center of gravity. I asked the class to locate the center of gravity in an embroidery hoop which I had brought. A bright girl replied immediately, "In the center!" This answer might have been a happy guess in view of the fact that we had just been talking about the *center* of gravity (nevertheless college students sometimes fail on this very point). I have never forgotten her surprised expression, however, when I quietly noted, that all the material could generally be considered as concentrated at that remarkable point, the center of gravity; in this instance none was there at all. The child began to realize that science might not be just common sense. The next day my daughter came home and reported excitedly, "Susie did it." "What?" I asked. "Why, that experiment you suggested yesterday!" "What experiment?" said I trying to recollect it. "The one about taking a chair and holding it up from different points to determine the center of gravity with a plumb line!" How many times had I suggested this experiment to my college students[8]—but no one had ever done it. "Susie did it!" Have our pedagogical difficulties been owing possibly to our careless attempt to present concepts at wrong psychological levels? Why not strive always to challenge young inquiring minds? The next part of my talk dealt with equilibrium, the various kinds that one finds with an ice cream cone. We investigated the equilibrium of a body on a hill, i.e., a board, by changing first the hill and then the body itself. We viewed the Leaning Tower of Pisa; we thought about the leaning girls in the annual tug of war. Of course, we became puzzled by that most stable equilibrium when the center of gravity exists below the

[8] R. J. Seeger, "Our Physical Heritage," (Ann Arbor, 1935).

point of support (a hammer and a stick, knives and a cup, a horse and a rider). Finally, we discussed animals, a horse with its center of gravity at the front end and a bear with it at the rear. A card table served as the model of a standing animal—sometimes with four legs and then with three. We discussed briefly the walking of animals—particularly some young people who prefer to crawl on all four. A girl illustrated the waitress's problem of balancing a tray with shifting utensils. I had no way of measuring the success—or failure—of my instruction. The reception and perception of the class did indicate attentive interest.

It occurred to me last spring that one should make a more definite effort to see whether or not physical concepts per se can be introduced in the elementary grades. A private school, Sidwell Friends, and the D. C. Public School System agreed to my proposal to teach physics to a third grade class on an experimental basis, say, for three periods each. My objective here was not only to present a physical concept, but at the same time to coordinate the science and the arithmetic. In the third grade one learns to multiply and to divide, at least, small integers. Accordingly, I decided to discuss machines. (An adult was curious as to how I intended to introduce ratios. I didn't!)

I arrived at the class with a bag full of simple machines from home; a pole, rope, scissors, pliers, hammer, tack lifter, tweezer, spoon, pencil, nutcracker, sugar tongs, etc. (That night the pupils made up a similar list of simple machines found in their own kitchens; some even brought unsolicited samples the next day.) "What is a machine?" I began. I push or pull on a machine, I exert an effort on it; the machine, in turn, pushes or pulls on something else, it handles a load. Machines always seem to make us wish to ask two interesting questions. How many times greater is the load than the effort? How many times farther must the effort move than the load?

In order to measure pulls and pushes, we examined a spring and then a spring balance. A single spring balance was made to pull one load and then two loads; a single load, in turn, was first supported by one spring balance and then by two. In general, we noted, two pulls in the same direction add, whereas opposite pulls subtract (apparently a new idea to most pupils). Next we examined pulleys; a single fixed pulley, a single movable pulley, and then a combination of the two. In each case the children themselves measured approximately the effort and the load (in "g" units), as well as the distance through which the effort moved and the corresponding distance for the load (in "thumb" units). We all calculated the number of times the load was greater than the effort, and then how many times greater the distance for the effort was than the distance for the load. I moralized that one never gets something for nothing; a price of some kind al-

ways has to be paid. I showed the operation of one complex pulley without such details. Next we went up a hill, i.e., a board in the form of an inclined plane. Here again we measured the load and the effort, the distance for the effort and the distance up for the load—for two entirely different loads. Finally, we took hold of levers. The children were all familiar with the see-saw on a pivot. Calling one side the effort and the other side the load, I introduced them to the so-called classes of levers, which depend upon the central position of the *pivot*, or the *load*, or the *effort*, respectively. (I could not help mentioning mnemonically that "ple" was the end of the word apple—after making certain of the accepted spelling of that word by the class.) We had a simple demonstration model (with sufficient friction not to be too student sensitive). We took a weight of three g's at a distance of two thumbs from the pivot. We balanced it with another weight of 3 g's at a distance of 2 thumbs on the other side, and then with weights of 1 g, of 2 g's, and of 6 g's, at appropriate distances. We balanced another weight of 3 g's at four thumbs and were astonished that the product of weight and lever arm remained the same for different counter weights. We guessed at the unknown weight needed for balancing another problem—and then verified it. On the last day after a brief review, I showed how a stick can be used as a lever of each class to open a box with a hinged cover. In passing, I noted that in pulling down with one's hand[9] the arm (the triceps being the effort) behaves as a lever of the first class with the elbow as the pivot. When one stands on tiptoe the ankle joint supports the load to make a lever of the second class (with the calf muscles as the effort). When one pulls up with one's hand, the biceps being the effort, the arm is a lever of the third class.

How effective were these presentations? The children themselves in both classes seemed interested, alert, and comprehending. The science teacher and the science supervisor, as well as the home-room teacher and the principal, who attended the talks in each school, were apparently satisfied with the general approach and with the material. In both instances the science teachers decided to follow up the work in a more leisurely fashion with the same class and to attempt a presentation de novo with another class in the same grade.

I gave a preliminary test before meeting each class. It consisted of multiple-choice numerical questions (with diagrams) involving two forces pulling together, two forces pulling in opposite directions; a single pulley, a movable pulley, a combination of the two; and finally, a see-saw with known weight and lever arm on one side and known lever arm only on the other side. In the private school class of 24 pupils where were 38 correct answers (7 being a perfect score)

[9] A. V. Hill, "Living Machinery," (London, 1927).

in the pre-test and 59 in the post-test (questions of the same general kind, but with different numerical values). A definite improvement, I believe, was thus shown. In comparing the scores on the individual questions, learning was evident in the cases of two forces pulling in opposite directions, of the movable pulley, of the pulley combination, and of the see-saw problem. Pulley distances seemed most troublesome to visualize. If I were repeating the experiment I would include some qualitative questions as well as the quantitative ones. As it was, I analyzed all incorrect answers as to greater and smaller results. The public school class of 29 children did not show any overall improvement in the written tests. Learning was achieved, however, for two forces in opposite directions and for the see-saw. My own explanation of the difference in the scores (of course, the questions themselves might not have been good) was not lack of interest or attention on the part of the youngsters, but rather a marked separation in the "intelligence levels." For example, in the highly selected group of the private school, the I.Q. ranged from 111 to 133 with the median of 123, whereas the public school (no numerical ratings available) low-selected class was average—down (the highest I.Q. being around 100, of which there were probably 5, and the average about 90, with 10 to 12 below 90). For the latter group one would still have to determine whether the material itself was too difficult, or the rate too fast. In both cases I gave some homework consisting of more difficult problems of the same type. As you might expect, several students achieved a perfect score of 10—in comparison with their test scores of 0 to 3. Who says that parents are not helpful?

This encouraging experience made me bold and eager to try an even lower grade. The Sidwell Friends School kindly assented to my request to meet with one second grade class and with one first grade class.

Second-graders can subtract, at least without having to borrow. I chose the subject of thermometers.[10] First of all, I pulled out of my pocket a clinical thermometer, familiar to most of the youngsters. We ascertained how many of us felt hot and how many cold. Then some children put one hand in hot water and the other one simultaneously in cold water—then both hands in lukewarm water. We were all amazed to find that the human body is unreliable. In looking for some other way of determining hotness, we saw that an iron metal ball (with a ring detector) expands when heated. The curling of a bimetallic strip was surprising, but understandable. We watched mercury expand upon warming a thermometer; we seemed satisfied with this means of determining temperature. Some pupils now used an "F" thermometer to find first the temperature of a mixture of ice and

[10] D. Roller, "The Early Development of the Concepts of Temperature and Heat," (Cambridge, 1950).

salt, then that of ice water, and finally that of boiling water. These values were listed on the blackboard in tabular form. Some of the youngsters already knew the temperature of the human body so that we were able to subtract the 32° point from it to find out how much hotter our bodies are normally than ice water. Some other children then measured temperatures with a "C" thermometer; first ice water, then boiling water, and finally a mixture of ice and salt, which produced a reading of about 18° below zero. "How much higher is the C 100° than this reading?" Immediately came the answer, "118!" How we disguise this simple reasoning by unnecessary complications like negative numbers, or even a formula! The temperature of some available water was next measured with the F thermometer. It turned out to be 40°. We all tried to guess the reading of the C thermometer. Someone then observed it. Our values had all been much too low. I would like to emphasize here the utilization of tables for guessing as a better introduction to physical approximation than a mathematical formula.

A first grader is apparently able to add combinations up to 10—largely by counting. I decided to talk to them about light.[11] We began by observing pictures with a pinhole source. In each instance, by moving our screen the same distance ("hand" unit) each time we found that the height of the image, too, increased by equal amounts (thumb unit). Several pinholes produced simultaneously several images, light apparently traveling in a straight line. An oatmeal box served as a handy pinhole camera. A large opening spoiled all our pictures, but a magnifying glass turned out to be useful as a lens. The first optical arrangement made the image the same size as the object. We then set up the object and screen at an arbitrary distance and focused the lens. Two images were found, a large one and a small one. It had been my intention to make a table of object and image distances and then to guess the image distance for a chosen object distance. I did not do so. Did I stop too soon?

This little practice teaching by an amateur has been sufficient to convince me that much can be done by a knowledgeable person genuinely interested in both the subject and the persons being taught. Let us, therefore, encourage our youngsters of all ages to experience nature scientifically, i.e., to observe phenomena directly, to measure them approximately, and to describe them simply—by physical concepts. To develop science teaching in the elementary grades becomes even more important for us physicists as we now look at the proposed revision of secondary school physics, which will omit

[11] W. H. Bragg, "The Universe of Light," (New York, 1934).
H. Hartridge, "Colours and How We See Them," (London, 1949).
H. Minnaert, "The Nature of Light and Color in the Open Air," (translation H. M. Kremer Priest; revision K. G. B. Jay, New York, 1954).

many elementary facts formerly included. At the same time we must necessarily envisage a new look for college physics, based realistically upon youngsters' experiences and maturity rather than upon technical terms which they may or may not have been taught—and have momentarily on their cerebral tips.

In this connection, I would recommend three principles for guidance in the construction of curricula. The first I will call the principle of genetic selection. It is important that we begin at the psychological, social, and intellectual levels of the child. In the above cases I myself have no definite idea as to whether the concepts I selected were particularly appropriate to the grades involved. What is obviously requisite is a systematic identification of physical concepts by study groups consisting of physicists, psychologists, and practicing teachers—all working together.

Cultural integration is the second principle. Those of us who are parents may become depressed by the sometimes too chaotic mixing of literature and sociology, of history and geography. Nevertheless, compartmentalization barriers are often needlessly artificial and should ultimately be broken down to conform more to natural areas and boundaries of studies. Mathematics and physics integrate quite naturally, they can be mutually helpful. One of the teachers, indeed, informed me that her youngsters had shown a greater interest in multiplication after having seen its usefulness in the lever demonstration. The chief difficulty to date has been our failure to treat science as an important subject in elementary curricula. Now that science is beginning to assume an educational role commensurate with its significance in our modern technological society, for the first time we can make proper use of this natural and mutually beneficial integration. From the standpoint of college physics, indeed, I am convinced that the most important need for entering students is not more and more, higher and higher mathematics, or even more scientific techniques and more modern physics, but rather an understanding of the application of some simple mathematics to some simple physical phenomena—what might appropriately be called mathematical science.[12] This relationship, above all else, must be cultivated early. Archimedes[13] still has much to teach beginning students of nature.

The third principle which I wish to emphasize for curricula selection is the principle of wholesome meaning.[14] A healthy life must be a combination of physical, mental, social (moral), and spiritual values. Accordingly, a wholesome education must include all these elements

[12] Report of the Joint Board on Science Education of the Greater Washington Area, "Science Curricula in Secondary Schools," *Journ. Wash. Acad. Sciences*, 48: 66 (1958).

[13] T. L. Heath, "The Works of Archimedes with the Method of Archimedes," (Reprint, New York).

[14] R. J. Seeger, "Frontiers of Science Education," *Workers with Youth*, 8 (Jan., 1959).

in a coordinated manner. For normal youngsters, perhaps, it is not so important that we heighten their scientific experiences; even more, we must widen their general outlook! We should regard them not as competitive teams attempting to climb spectacular mountains of achievement, but rather as adventuresome individuals out to enjoy the expansive plateaus of learning. Comprehension which involves insight is far more significant than acquaintance which involves mere sight. In a recent book[15] Werner Heisenberg has likened a teacher to an illuminator of landscapes. He noted, "Very occasionally, an object that has thus come into our field of view will suddenly begin to shine in its own light, first dimly and vaguely, then even more brightly, until finally it will glow through our entire mind, spill over to other subjects and eventually become an important part of our own life." Evidently one must allow sufficient exposure time for such a process to start—and then a period of incubation. Education involves organic growth, not just material acquisition.

Physics can be fun at all ages for all people! In a chapter[16] headed "Science, Art and Play" Erwin Schrödinger once wrote, "The chief and lofty aim of science today, as in every other age, is the fact that it enhances the general joy of living. . . . It is the duty of the teacher of science to impart to his listeners knowledge that will prove useful in their professions; but it should also be his intense desire to do it in such a way as to cause them pleasure." Let us enable our children to enjoy their physical environment! The sources of happiness in living are not so many that we dare deprive them of their rightful intellectual heritage.[6]

[15] W. Heisenberg, "The Physicist's Conception of Nature," (translation, A. J. Pomerans, New York, 1958).
[16] E. Schrödinger, "Science Theory and Man," (New York, 1957).

ELECTRONIC LUNG REPLACES IRON LUNG

Following extensive research and close cooperation between the medical profession and precision engineers, an electronic lung which can replace iron lungs, has been perfected.

Called the Barnet Ventilator, the lung has been a joint venture by several British electronic companies, each of which contributed specialized knowledge and technical facilities. The instrument is manufactured by W. Watson & Sons, Ltd., a member of the Pye Instrument Group of Cambridge, England

Treatment by means of the Barnet Ventilator gives the patient considerable freedom. Instead of being encased in a box the patient is linked to the Ventilator by two plastic tubes. Breathing is sustained by the alternation of positive and negative pressure, air being pumped into the lungs during the positive phase and extracted during the negative.

Step Function Notation

John L. Spence

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The usefulness of the unit step function in the treatment of discontinuous phenomena has long been recognized. This writer, however, knows of no text that gives a simple, mathematical definition of the unit step function. Most texts on advanced calculus, Laplace transformations, etc., give only verbal definitions of this very useful function. A popular definition of the unit step function, $U(x-A)$, is

$$\begin{aligned} U(x-A)&=0 \text{ if } x<A \\ U(x-A)&=1 \text{ if } x>A \end{aligned},$$

where x and A are real numbers.

Unfortunately, the "if's" of the above definition cannot be handled mathematically. Even though it is unwieldly, the above definition of the unit step function suffices when used only to develop step functions. It is, however, almost useless in handling many types of discontinuities. It seems that a more universal and versatile definition of the unit step function should be used.

It is believed that the absolute value notation provides a rather simple method of defining the unit step function. This definition is mathematical, that is it is given in simple equation form, and may be handled as any other elementary equation. Letting $Q(x)$ be the symbol for the unit step function, and when x and A are real numbers, one may write

$$Q(x)=\frac{1}{2}\left[\frac{/x-A/}{x-A}+1\right].$$

It is easily verified that the graph of $Q(x)$ is identical to the graph of $U(x-A)$. A comparison of the two methods of notation is shown by the two following definitions of the function which is graphed in Figure 1.

$$y=-x+2+2(x-2)[U(x-2)] \quad \text{(Conventional notation).}$$

$$y=/x-2/ \quad \text{(Absolute value notation).}$$

Aside from the greater simplicity of the equations used, the absolute value functions are subject to all conventional mathematical operations.

Rule for Differentiation

$$\frac{d(A/U/^n)}{dx}=\frac{nA/U/^n}{U}\cdot\frac{dU}{dx},$$

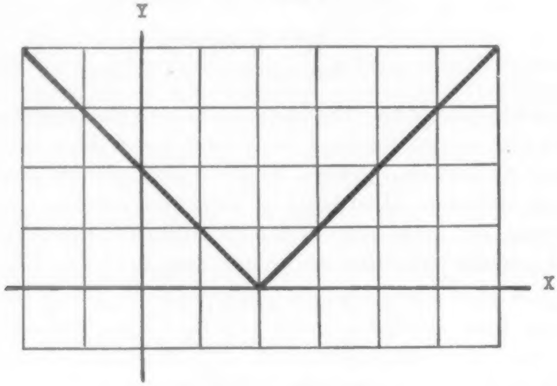

FIG. 1. The Graph of $y=/x-2/$.

where U is any function of x.

This rule for the differentiation of absolute value functions is easily proven by using the conventional definition, $/U/=\sqrt{U^2}$, and then applying the standard rules for differentiation.

Rule for Integration

The nth successive integral (anti-derivative), Z_n, of $Q(x)$ is given by

$$Z_n=\frac{(x-A)^n}{n!}\,[Q(x)]\cdot$$

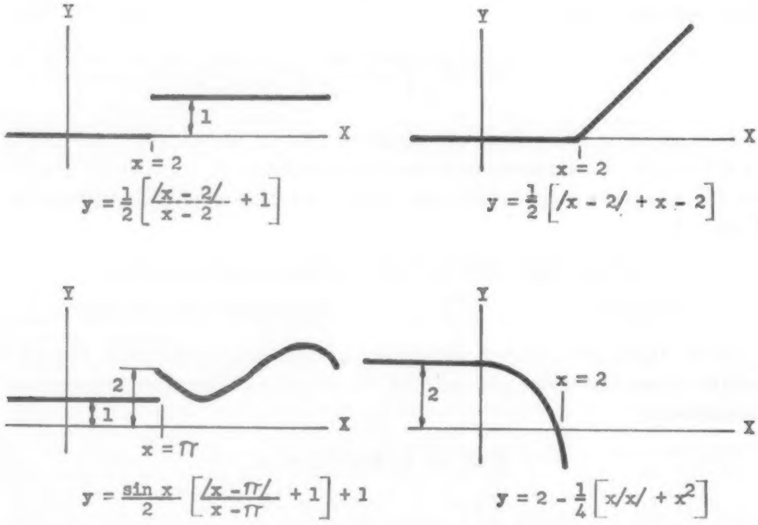

FIG. 2. The graphs and equations of some typical absolute value functions.

Utilizing our Total Educational Potential: Science for the Slow Learner

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A major problem arising from the current reappraisal of science education is the danger that, in our eagerness to raise standards for the average and above-average student, we may lose sight of the needs of a large segment of our pupil population. Our slow learners are always with us. Some teachers may view them as a nuisance and a liability. Yet we have the obligation to educate them as citizens of our country, having the same rights and privileges as pupils in the upper strata of the intellectual scale. Successful teachers of slow learners find their work with this group unusually satisfying. But others have difficulty in adapting themselves to the requirements of such pupils. Some practical suggestions based on the background of experience accumulated by many teachers of pupils of limited ability may be of some assistance.

Characteristics of the Slow Learner

Not all of the pupils included in this group will show the complete range of traits listed here, but many of these characteristics will appear in any class of slow learners. The teacher must take them into account in selecting curriculum materials, planning instructional activities, and providing for adequate guidance.

In general, the I.Q. range will be from 90 to 75. Coupled with this is poor reading ability. Most slow learners in the secondary schools have a reading retardation of two or more grades. The attention span of these pupils is unusually short. They need interesting and varied approaches to learning. They are usually unable to grasp abstract ideas. Physically, they may appear to be bigger than other pupils on their grade level, but investigation usually reveals that they are older than their classmates because of prior retention in the lower grades. As a matter of fact, they have a greater incidence of such physical defects as poor sight or hearing.

Many teachers believe that they they have greater manual dexterity than the average, and as a result, extensive shop programs have been set up in some schools where there are large numbers of slow learners. Some science teachers have tried extensive project programs and individual laboratory work. But although some individuals are able in manual work, for many the supposed dexterity proves to be a myth.

How many slow learners are there in our schools? Purely statistical analysis indicates that about 30% of our pupils fall into this category.

In some schools located in favored areas, the percentage may be much smaller, but in schools serving children of depressed socio-economic background, 50% or more of the pupils may have severely limited learning ability.

Selection of Content

The slow learner cannot cope with the same course of study as other pupils. Because of his failure to grasp abstract ideas, he must be exposed to subject matter related to his level of ability. The intricacies of the dihybrid cross, Boyle's Law, and chemical calculations are not for him. Yet "watered down" versions of the standard courses in general science, biology, chemistry, and physics, do not seem to work very well.

Emphasis must be placed on practical, *functional* material. Vocational applications, mental and physical health, topics related to home and family life—in fact, anything that satisfactorily answers the question: "Why do we have to learn this?"—may be taught to these pupils.

To illustrate this, we may contrast the traditional treatment of the topic, *Behavior*, with the approach used in a slow biology class. The usual content includes a study of tropisms in lower forms of life, the mechanism of the reflex arc, a rather detailed study of the structure of the nervous system, habits, and conditioning. With slow classes, the study of tropisms may be eliminated. The emphasis is on *human* behavior. Reflexes are taught by experiments, with the students themselves as subjects. The *usefulness* of reflexes as protective mechanisms would be stressed. Conditioning is taught as a method of training animals, as a factor in the development of groundless fears, and as a form of learning. Habit formation becomes useful information when applied to the good and bad habits of the students themselves. The class then progresses to the study of intelligence, the measurement and meaning of "I.Q.," and the relationship between I.Q. and such factors as industry, ambition and character to success in life. The problems of teen-agers and their relations with their parents and others around them may be considered. In general, the academic is subordinated to the interesting and the useful.

In science, there is a heavy overload of technical vocabulary. This should be reduced to a minimum in dealing with slow learners. While they may show a superficial interest in "big words," they can neither understand them nor learn their meanings.

Slow learners can learn, but at a slower pace. With most groups, only three or four large units can be covered in the course of a year's work. Yet, a surprisingly adequate body of useful information can be taught if the subject matter is carefully selected and presented.

Methods of Teaching

It is impossible to be dogmatic in prescribing methods of teaching for classes of slow learners. What succeeds for one teacher may be a dismal failure in the classroom of another. Much depends upon the personality and background of experience of the individual teacher and the makeup of the pupils in his class. Nevertheless, some broad principles of method may be laid down for trial (and possible error).

A majority of teachers report that the traditional "development lesson" does not work well with slow learners. One of our colleagues has compared it to a game of tennis . . . with the teacher as the only player. You hit the ball over the net, jump over the net and hit it back, and so on to the end of the session. A sustained discussion is a rarity in such classes.

Outside reading and written reports are usually ineffectual. The common result is the submission of pages of material (complete with misspellings), carefully copied from a book or encyclopedia without a trace of real understanding.

If these time-tested methods do not work, what can we rely upon? To begin with, we can counteract the short attention span of the slow learner by utilizing a *variety* of procedures in the course of a single period. In a lesson on magnetism, the teacher can give a brief demonstration, use the blackboard, show a film, and summarize with a short reading assignment. Watching for signs of lagging interest, he will change his procedure when the attention of the class begins to wander.

Because slow learners need specific direction, the aims of each lesson should be exceptionally clear. After a brief, interest-stimulating motivation (such as a spectacular demonstration, the discussion of a current news item dealing with the topic, or an interesting story told by the teacher), the step-by-step procedure for the period should be outlined on the blackboard. For example: "The topic for the day is Polio. We will see a short film and answer questions based on it. Then read pages 6 to 10 of the pamphlet, 'Protection Against Polio.' Write the first six questions on page 16 in your notebook and answer them. For extra credit, you may answer questions 7 to 10 on page 16. The questions will be discussed at the end of the period."

Improvement in reading is perhaps the greatest need of the slow learner. Ten or fifteen minutes of silent reading in class may be part of almost every lesson. Because understanding is the chief goal, the pupils should be required to answer questions based directly on the assignment. Again, to provide direction, the assignment and its accompanying questions must be precise. In addition to silent reading, pupils may be asked to read aloud. This technique should not be attempted before the class has become well organized, perhaps six weeks or more after the beginning of the school year. If the members

of the class do not know each other well, they will hesitate to reveal their marked deficiencies by reading aloud. Slow pupils like to listen to a reading given by their teacher, and this procedure is very helpful to them in their struggle to learn. Finally, to provide the needed variety, an adequate supply of suitable supplementary material should be available in addition to the basic textbook.

Individual help to pupils characterizes the work in a class of slow learners. While they are occupied with their reading assignments, the teacher can visit individual students, giving help where needed. Incidentally, the true slow learner can rarely use a dictionary effectively, and he must rely on the teacher to clarify the meaning of a word or phrase.

Many pupils are talented in art work or construction. We can capitalize on their abilities in the making of drawings, posters, models, charts, and pieces of equipment. One of the best models of a rocket launching site I have ever seen was constructed by a boy with an I.Q. of 79. Such activities stimulate interest in science and give the pupils a badly-needed feeling of achievement.

Audio-visual instruction is particularly useful with slow learners. However, the films and other materials used must be selected with care. Teachers report that some of the most popular sound films are far "over the heads" of these pupils. In such cases, we generally find that the sound track is not understood. Film strips seem to be quite effective. A good technique is to ask individual pupils to read the title frames aloud. By associating the words with the pictures, they are often able to comprehend the written material better than passages in books.

The student's notebook can be a medium of instruction, an outlet for individual expression, and a source of pride in achievement. Definite standards should be set up at the beginning of the school year. It is advisable to ask the pupils to write these on the first page of the notebook. Completeness, neatness, and accuracy should be stressed. The notebook is a summary of the work of the class, an essential aid to study, and a basis for rating. At frequent intervals, notebooks should be checked and graded by the teacher.

Materials of Instruction

It is axiomatic that reading materials used by slow learners should be on their reading level. However, we may overlook the fact that such materials must also be on their level of interest and maturity. Books written for fifth or sixth grade pupils are easy enough to read, but the subject matter or style of writing may be considered too childish by secondary school students. An illustration showing younger children working with scientific apparatus may provoke a

violent rejection of the book because of its undesirable psychological effect on the pupils. Free or inexpensive materials distributed by industrial and similar organizations are often useful. Science textbooks written specifically for slow learners and pupils of limited ability are now more widely available.

Complex apparatus should not be used to demonstrate scientific principles where simpler materials are equally useful. Home-made equipment is good. Many of the charts used in other classes are incomprehensible to slow learners. Models, charts, and mimeographed workbooks produced by teachers or pupils are often better.

Testing and Grading

Slow learners show just as much interest in marks as other pupils. The basis for marking should be effort, interest, and cooperation. Short tests should be given frequently. The most effective types of tests are objective examinations utilizing multiple choice and matching questions and diagrams. The questions must be short and carefully designed to match the reading ability of the pupils. At times, open book or open notebook tests may be given. The notebook should be a major factor in estimating the grade of the pupil. Each individual must have the feeling that, despite repeated past failures, he can succeed in the science course if he works to the limit of his ability.

Some schools place an upper limit on the grades that may be given to pupils enrolled in a class of slow learners. This practice often creates difficulties for the teacher. He may be faced with the problem of explaining an artificially low grade to a pupil who has done excellent work as a result of intensive effort. It is best to place no limitation on grades, but some identifying designation may be placed on the pupil's record if necessary.

Attitude of the Teacher

Successful teachers of slow learners need not have great depth in subject matter background, but they must be warm, sympathetic, patient, and helpful. It is a common experience to find the most recalcitrant pupils responding to the encouragement and guidance offered by such teachers. A class of slow learners will readily cooperate with someone who understands their problems, and they will often exert great effort to please him. Praise, not censure, is the most effective procedure. These pupils need assurance and a helping hand. Under such circumstances, they will show appreciation and affection. Many teachers of slow learners will attest to the fact that there are satisfactions to be gained by teaching such pupils that cannot be gained with other classes.

It is our responsibility to develop the potential of all of our students. As the late Edward T. Jewett said in a recent address: "Slow learners are not a national loss. What they learn sticks and they mostly —if given their chance—turn into solid citizens who work with their hands, buy homes on time, raise and educate families, and will make parts and put together space ships from the blueprints of the genius."

SPRING MEETINGS OF THE ILLINOIS COUNCIL OF TEACHERS OF MATHEMATICS

Date	*Place*	*Chairman*
March 26, 1960	East St. Louis High School East St. Louis, Illinois	Rachel Kuehn

Principal speakers:
Dr. J. J. Urbancek, Chicago Teachers College
Mildred Cole, Junior High School, Aurora, Illinois
Dr. Kenneth Henderson, University of Illinois, Urbana, Illinois

April 2, 1960	Illinois State Normal University Normal, Illinois	Albert Eckert

Theme: Challenges in Mathematics

Principal speakers:
Dr. C. B. Read, University of Wichita, Wichita, Kansas
Dr. M. L. Hartung, University of Chicago

April 9, 1960	Western Illinois University Macomb Illinois	Arnold Wendt

Principal speakers:
Dr. Franz Hohn, University of Illinois, Urbana, Illinois
Dr. G. H. Gundloch, Bowling Green State University

April 11, 1960	Eastern Illinois University Charleston, Illinois	Ferrel Atkins

Principal speakers:
Dr. R. V. Andree. University of Oklahoma
Dr. M. L. Hartung, University of Chicago

April 16, 1960	Southern Illinois University Carbondale, Illinois	Martin R. Kenner

Principal speaker: Dr. Paul C. Rosenbloom, University of Minnesota

Panel: Developmental Mathematics Project at Southern also Field Day for High School students

April 30, 1960	J. Sterling Morton High School (West) Cicero, Illinois	Hobart Sistler

Theme: The Articulation of Mathematics from Kindergarten through College

Principal speakers:
Dr. Phillip Peak, University of Indiana
Dr. M. L. Hartung, University of Chicago
Dr. Max Beberman, University of Illinois
Dr. Karl Manger, Illinois Institute of Technology

On Computer Components and Data Processing

Enoch J. Haga

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Automatic data processing may be looked upon as the most recent attempt to solve a very old problem—the problem of how to reduce a mass of raw information to usable form. Data processing equipment, from adding machine to UNIVAC, has been devised to lighten the load and solve this problem in a better, more efficient manner. The problem is basically one of classifying, sorting, calculating, summarizing, and recording data, and all data processing equipment is designed to perform one or more of these five basic operations. The adding machine made it possible for a single machine to replace the dual functions of summarizing and recording. Later, tabulating equipment, consisting of key punches, sorters, reproducers, accounting machines, and other devices, were integrated by means of the punched card. This means that while each machine performs a specific function, or combination of functions, the punched card makes all the equipment mutually compatible. This means that the same data can be handled on different machines by moving the cards that contain the data. It is not necessary to obtain duplicate data for use on each machine. Today punched tape makes possible the integration of even more equipment; any office machine, from a typewriter to a calculator, can be made to produce a punched tape as it operates, and this tape may be used to integrate and make compatible not only conventional office machines, but punched card equipment as well. This degree of integration is referred to as *integrated data processing.*

But integrated data processing involves manual transfer of tape or cards from machine to machine. The latest development, *electronic data processing,* gets around integration with intercommunication, the automatic integration of basic data handling operations. The concept is shifted from use of single machines, such as adding machines, desk calculators, and tabulating equipment, for working independently on segments of the data processing problem, to utilization of entire batteries, or systems of equipment, for achieving completely automatic handling of the whole data processing problem. All five data handling operations are performed at the speed of light on data processing systems capable of following stored directions automatically from start to finish of any data handling job. To get its job done the electronic equipment "talks to itself."

Components of Electronic Systems

Electronic systems process data by means of an electronic com-

puter, but there must also be a means of getting the data to be processed into the computer and a means of taking it out. These means for getting data into and out of a computer are commonly known as *input* and *output* devices. The computer itself has arithmetic, control, and memory units. The computer units are sometimes referred to as "electronic brains" and the memory units have been especially regarded as the "hearts" of the electronic systems.

Some common input devices are magnetic or paper tape or punched card readers. All kinds of sensing devices fall into the input class, for example, photoelectric scanners. Output devices are commonly paper tape or punched card punches, magnetic or photographic records, printers of various sorts, or visual displays. The Stromberg-Carlson visual display tube, *Charactron*, is capable of minutely reproducing alphameric (letters or numbers) data at the rate of ten to fifteen thousand characters a second. The tube-screen is photographed at a speed fast enough to copy a three hundred page book in thirty seconds.[1] A similar device is the Hughes *Typotron* tube, a component of the SAGE master weapons control system. The *Typotron* is capable of read-out at twenty-five thousand characters a second.[2] Burroughs has also made a coin-size glow tube called *Nixie*.[3]

The memory or storage element is the most important device in any computer, and there are several types with varying technical characteristics. A memory device simply stores information inside (or outside) the computer until it is needed—Charles Babbage (1792–1871), father of today's "giant brains," as a matter of fact, actually called the memory for his *engine* a *store*. Magnetic drums, tape, discs, cores, belts, and wire are some of the media used. Others are electrostatic storage tube, punched card and tape, plugboard, and so on.[4] Some new developments are the Magnavox *Magnacard*, a one by three inch magnetic card capable of storing six hundred alphameric characters,[5] and the photochromic process of the National Cash Register Company; in this process information stored in dye cells may be read by light beam; one square foot of the paper used will hold twenty million bits.[6]

Next is the arithmetic component, which is incidentally not strictly limited to arithmetic functions; there are several logical operations applicable to the computing field. Thus, since it may reason in both numerical and non-numerical terms, an arithmetic component might

[1] *Computers and Automation*, 5: 28, December, 1956.

[2] *Scientific American*, 198: 126–127, March, 1958.

[3] "A Pictorial Introduction to Computers," *Computers and Automation*, 6: 54, June, 1957.

[4] "Components of Automatic Computing Machinery—List of Types," *Computers and Automation*, 6: 24–25, March, 1957.

[5] "Magnacard" (Fort Wayne: The Magnavox Company, c. 1958).

[6] *Newsweek*, 50: 102, November 25, 1957.

more properly be designated a logical component. An arithmetic unit may be called upon to solve purely arithmetic problems, and also to do such things as compare, transfer, and combine. There is intercommunication between arithmetic and memory—one component can go to the other for information as often as required. A computer utilizes complex circuits, inexplicable except in technical terms, but a rough idea of how the arithmetic device operates may be fairly simply explained: the system is even simpler than Morse code dot-dash, because there is either something happening, or there is nothing happening; that is, there is either a sub-millisecond pulse or the absence of a pulse. This binary numeric system, which of course may be used to represent letters in the alphabet (or other characters), has a base of two, a pulse or no pulse, one or zero. The numbers zero to thirty-two are listed below in both decimal and binary form:

0	0	11	1011	22	10110
1	1	12	1100	23	10111
2	10	13	1101	24	11000
3	11	14	1110	25	11001
4	100	15	1111	26	11010
5	101	16	10000	27	11011
6	110	17	10001	28	11100
7	111	18	10010	29	11101
8	1000	19	10011	30	11110
9	1001	20	10100	31	11111
10	1010	21	10101	32	100000

The binary system obeys all the usual laws of arithmetic:

$$2(32)=64 \qquad \text{or} \qquad \begin{array}{r} 100000 \\ \times 10 \\ \hline 1000000 \end{array}$$

$$30/5=6 \qquad \text{or} \qquad \begin{array}{r} 110 \\ 101\overline{)11110} \end{array}$$

$$12+13=25 \qquad \text{or} \qquad \begin{array}{r} 1100 \\ +1101 \\ \hline 11001 \end{array}$$

$$29-9=20 \qquad \text{or} \qquad \begin{array}{r} 11101 \\ -1001 \\ \hline 10100 \end{array}$$

One or usually more binary digits are the equivalent of each decimal digit, letter of the alphabet, or symbol. A binary digit is designated a *bit*, and a group of bits constitute a *character* (decimal number, letter, or symbol). Characters are handled by computers in the form of *words* of either uniform or variable length. A group of words then constitute a *block*. On the UNIVAC each block is composed of six *blockettes;* each blockette comprises 120 digits. Ordinarily taped magnetic impulses are not visible to the naked eye, but through use of a solution of finely ground particles of metal, the distribution of pulses on the phosphor-bronze magnetic tape may easily be seen; for the magnetized pulses will attract the metal filings in the solution and form a pattern.

Last, but by no means least in importance, is the control component. This unit has intercommunication with memory, and it sees that the computer does, according to scheduled sequence or program, the job it has been "told" to do.

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STUDY METALS FOR EFFECTS OF SUN'S HEAT

Radiation from the sun can be man's enemy, or an almost unlimited source of energy, if controlled and harnessed.

The harnessing calls for the right equipment, and two University of California engineering professors are now studying and testing different materials for making the equipment.

Under a $51,000 grant by the National Science Foundation, they are beginning a two-year investigation of the spectral characteristics of metals which determine how much of the sun's heat a metal will absorb, transmit or reject.

The two engineers will test existing materials, but also try to develop special metal coatings and films for solar energy equipment.

A Study of the Relationships of Non-Academic Correlates to Achievement—Participants and Non-Participants in the National Merit Scholarship Testing Program*

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Introduction

Since the launching of the Russian satellites, much has been said about the shocking lack of scientific education of American youth. In proposing solutions for our current educational needs, however, we must not be misled into thinking it is simply a matter of turning out greater quantities of scientists and engineers.

These are years of challenge and opportunity for our young people. Tremendous advances in science during the last twenty-five years have resulted in a demand for more scientists, more engineers, more technicians, and more trained workers. These are years that pose great problems for industry, for government, and for education. With the advent of "Sputnik," these are critical years for our country.

The proper education of most of our boys and girls is a problem of major significance. Action on behalf of the academically talented student—the student who can study effectively and rewardingly such academic subjects as advanced mathematics and foreign languages—demands understanding.

Critical evaluation, by men of high professional standing, that the superior student has been neglected in our public schools in the past, is anything but conclusive. Much has been done with the problem of identifying and educating the academically talented pupil. Many public schools have had enriched programs and many have placed no limit on academic attainment. Secondary schools across the United States are increasingly improving and providing for their academically talented and able students.

It appears that the quality and the quantity of the educational achievement of the superior students have often seriously limited their later academic performance. How much sufficient information based on research do we have regarding the circumstances that surround high academic achievement? It appears to the writers that too little is known about non-academic correlates, which may be as potent in high-level achievement as the academic correlates. For example, Paul F. Brandwein[1] poses the hypothesis that three factors—

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* This article is based on the findings of the unpublished Master of Science in Education thesis completed by George J. Silovsky at the University of Kansas in September 1959.

[1] Paul F. Brandwein. *The Gifted Student As Future Scientist.* Harcourt, Brace and Company, 1955. 107 pages.

Genetic, Predisposing, and Activating—are all necessary for the development of high-level ability in science and that no one of them is sufficient in itself.

Plan and Purpose of the Study

Past research has indicated that the capacity or the potential of a student alone will not insure the development of giftedness; there must be, too, both motivation and opportunity to use and develop these talents. Social, ethnic, and economic background factors are important in enhancing or determining motivation.

During the Spring of 1958, about 7,000 Kansas high school students in over 300 Kansas secondary schools completed the *National Merit Scholarship Test.* During the school year 1958–1959, when some students were asked to complete an eight-page questionnaire, five students in each school who had not taken the test were also asked to complete the questionnaire. The students were called participants and non-participants. The final returns show about 4,675 questionnaires for the first group and about 1,028 questionnaires for the second group. Included in the questionnaire[2] were three sets or clusters of items pertaining to non-academic correlates of achievement. The questions were:

Cluster A (Parental Factors)

1. What is (or was) the formal education of your father or guardian?
   1—Did not attend school
   2—Did some grade school work
   3—Finished grade school
   4—Did some high school work
   5—Graduated from high school
   6—Did some college work
   7—Received a college degree
   8—Received more than one college degree
2. What is (or was) the formal education of your mother or guardian? (Use the same code as in 1)
3. How do you estimate the ability of your parents to help you go to college, if you desire to go?
   1—Cannot afford it
   2—Can afford it, but with much sacrifice
   3—Can easily afford it
4. How would you rate your family in terms of income or wealth of families in your community?
   1—Considerably below average
   2—Somewhat below average
   3—Average
   4—Somewhat above average
   5—Considerably above average
5. What attitude is characteristic of your parents about your going to college?
   1—Will not let me go
   2—Do not care whether I go
   3—Want me to go to college

[2] Kenneth E. Anderson. University of Kansas General Research Project 4542-5570: A Study of the 1958 Kansas Participants in the National Merit Scholarship Program.

Cluster B (Educational Factors)

1. How do you rate the educational opportunities offered by your high school in regard to preparation for college work?
   1—Very inferior
   2—Inferior
   3—Good
   4—Very good
   5—Superior
2. How satisfied are you with your own academic achievement thus far in high school?
   1—Thoroughly dissatisfied
   2—Somewhat dissatisfied
   3—Satisfied
   4—Thoroughly satisfied
3. What are your studying conditions at home or where you live?
   1—Inferior. It is difficult for me to study because of frequent interruptions or other disturbances.
   2—Average. I am disturbed now and then.
   3—Very good. I am usually undisturbed.
   4—Excellent. When I want to study I am very seldom disturbed by anybody or anything.
4. What influence have your teachers had on your plans to go to college?
   1—Discouraged me from going to college
   2—Have had no effect on my decision
   3—Encouraged me to go to college

Cluster C (Self-Evaluating Factors—Intellectual Curiosity and Persistence)

1. How would you rate yourself in terms of intellectual curiosity? (Do you frequently ask yourself why a particular thing is so or how do I know it is true?)
   1—Considerably below average
   2—Somewhat below average
   3—Average
   4—Somewhat above average
   5—Considerably above average
2. How would you rate yourself in terms of willingness to stand discomfort (a cold, illness, etc.) in completion of a school task?
   1—Considerably below average
   2—Somewhat below average
   3—Average
   4—Somewhat above average
   5—Considerably above average
3. How would you rate yourself in terms of willingness to spend time, *beyond the ordinary schedule*, in completion of a given school task?
   1—Considerably below average
   2—Somewhat below average
   3—Average
   4—Somewhat above average
   5—Considerably above average
4. How would you rate yourself in terms of *questioning* the absolute truth of statements from textbooks, newspapers, and magazines or of statements made by persons in position of authority such as teachers, lecturers, and professors?
   1—Considerably below average
   2—Somewhat below average
   3—Average
   4—Somewhat above average
   5—Considerably above average.

From the returns which totaled 5,703, fifty schools were selected at random for an exploratory study of the three clusters of items. For each non-participant in a school, an equal number of participants was chosen at random from that school. The sample finally consisted of 100 participants and 100 non-participants. The Science Composite Scores and Humanistic Composite Scores on the *National Merit Scholarship Qualifying Test* were recorded for these 200 students.

Three scores for Clusters A, B, and C as indicated above, were secured for each student in the study by adding the numbers in the boxes. Thus, if a student scored a 5 (considerably above average) for items 1, 2, 3, and 4 in Cluster C, his score for the Group C Cluster would have been 20.

The purpose of this study was threefold. First the writers attempted to discover the circumstances and conditions which apparently influenced some pupils of superior ability to a high level of accomplishment; and secondly, attempted to correlate certain non-academic factors with the Humanistic Composite Scores and the Science Composite Scores achieved on the *National Merit Scholarship Test*, and to ascertain whether these correlations showed any significance at the one per cent level. Lastly, to ascertain whether there were significant differences at the one per cent level between participants and non-participants on these non-academic factors.

Results of the Analysis

Three t tests were run to ascertain the existence of significant differences between the participants and non-participants on the three clusters of non-academic items. The writers assumed that the distribution of scores for the clusters of items (A, B, and C) were normally distributed in the population. If this were the case, were the participants and the non-participants random samples from the same population? The groups being compared were not tested for homogeneity of variances. Johnson states: "Where the size of the samples is the same, where $N_1 = N_2$, the significance of the differences between means can be determined even though the variances differ, by calculating t in the usual way. However, the t table is entered with d.f. $= N_1 - 1 (= N_2 - 1)$ instead of $N_1 + N_2 - 2$."[3] The results of the three t tests appear in Table 1 and indicate that the Participant Group scored significantly higher than did the Non-Participant Group on the clusters of items labeled Parental and Self-Evaluating.

The writers dealt next with obtaining correlations between the Science Composite Scores and scores on each one of the three clusters

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[3] Palmer O. Johnson, *Statistical Methods in Research*. Prentice-Hall, Inc., 1949, p. 75.

TABLE 1

COMPARISON OF 100 PARTICIPANTS AND NON-PARTICIPANTS ON THREE CLUSTERS OF NON-ACADEMIC ITEMS

Cluster	Participants (Mean)	Non-Participants (Mean)	t value
A: Parental	17.55	16.40	2.74*
B: School	10.99	10.74	1.09
C: Self-Evaluating (Intellectual Curiosity and Persistence)	14.23	12.78	5.00*
N	100	100	

* Significant at the one per cent level.

of items (A, B, and C), and between Humanistic Composite Scores and scores on each one of the three clusters of items (A, B, and C). Tables 2 and 3 indicate the correlations obtained in each case. The results in Table 2 indicate that the only significant correlation at the one per cent level was the one for the Humanistic Composite Scores, and the scores on the cluster of items labeled Self-Evaluating (Intellectual Curiosity and Persistence). The results in Table 3 indicate that significant correlations at the one per cent level were obtained between the scores on the clusters of items labeled Parental and Self-Evaluating (Intellectual Curiosity and Persistence), and the Science Composite Scores.

A different sample of 50 students produced the results shown in Tables 4, 5, and 6.

A word of explanation is pertinent at this point about the composite scores used in computing the correlations. The Science Composite Score gives a greater proportional weight to the sub-tests, Mathematics Usage and Natural Sciences Reading, while the Humanistic Composite Score gives a greater proportional weight to the sub-tests,

TABLE 2

CORRELATIONS FOR THE THREE CLUSTERS OF ITEMS AND THE HUMANISTIC COMPOSITE SCORES FOR 100 PARTICIPANTS IN THE NATIONAL MERIT SCHOLARSHIP QUALIFYING TEST PROGRAM

Cluster	Coefficient of Correlation
A: Parental	.02
B: School	.18
C: Self-Evaluating (Intellectual Curiosity and Persistence)	.60*
$N=100$	

* Significant at the one per cent level.

English Usage, Social Studies Reading, and Word Usage. Each provides valuable guide lines to students who wish to enter these and related fields.

TABLE 3

CORRELATIONS FOR THE THREE CLUSTERS OF ITEMS AND THE SCIENCE COMPOSITE SCORES FOR 100 PARTICIPANTS IN THE NATIONAL MERIT SCHOLARSHIP QUALIFYING TEST PROGRAM

Cluster	Coefficient of Correlation
A: Parental	.73*
B: School	.18
C: Self-Evaluating (Intellectual Curiosity and Persistence)	.48*
$N=100$	

* Significant at the one per cent level.

TABLE 4

COMPARISON OF 50 PARTICIPANTS AND NON-PARTICIPANTS ON THREE CLUSTERS OF NON-ACADEMIC ITEMS

Cluster	Participants (Mean)	Non-Participants (Mean)	t value
A: Parental	18.77	17.44	1.43
B: School	11.60	10.88	1.77
C: Self-Evaluating (Intellectual Curiosity and Persistence)	15.06	13.23	3.18*
N	50	50	

* Significant at the one per cent level.

TABLE 5

CORRELATIONS FOR THE THREE CLUSTERS OF ITEMS AND THE HUMANISTIC COMPOSITE SCORES FOR 50 PARTICIPANTS IN THE NATIONAL MERIT SCHOLARSHIP QUALIFYING TEST PROGRAM

Cluster	Coefficient of Correlation
A: Parental	.37*
B: School	.18
C: Self-Evaluating (Intellectual Curiosity and Persistence)	.42*
$N=50$	

* Significant at the one per cent level.

TABLE 6

CORRELATIONS FOR THE THREE CLUSTERS OF ITEMS AND THE SCIENCE COMPOSITE SCORES FOR 50 PARTICIPANTS IN THE NATIONAL MERIT SCHOLARSHIP QUALIFYING TEST PROGRAM

Cluster	Coefficient of Correlation
A: Parental	.23
B: School	.22
C: Self-Evaluating (Intellectual Curiosity and Persistence)	.44*
$N=50$	

* Significant at the one per cent level.

SUMMARY

The purpose of this study was to determine what circumstances and conditions influence some people of superior ability to a high level of accomplishment. A second purpose was to correlate the scores on non-academic factors with the Humanistic Composite Scores and the Science Composite Scores as achieved on the *National Merit Scholarship Test,* and to ascertain which of these correlations were significant at the one per cent level. Lastly, to ascertain whether there were significant differences at the one per cent level between participants and non-participants on these non-academic factors.

The results of this study suggest that the students who aspired to a National Merit Scholarship or who were sufficiently motivated to take the test, tended to score themselves significantly higher on the parental items and tended to rate themselves significantly higher on the Self-Evaluating (Intellectual Curiosity and Persistence) items than did the non-participants. The latter was true in both the samples of 100 and 50. Whether tendency to rate is the same as possession of these traits is open to question; but if this is true, did these factors carry over into achievement as measured by the *National Merit Scholarship Test?* The answer seems to be in the affirmative, especially as far as the Self-Evaluating items were concerned, as positive and significant correlations were obtained between the self-scores on these items and the Humanistic and Science Composite Scores on the *National Merit Scholarship Test.* This was the case for both the samples of 100 and 50. Thus it would seem that high ratings on two clusters of items, parental but especially self-evaluating, tend to be accompanied by high achievement scores in the humanistic and science areas.

It would seem on the basis of the above evidence, fragmentary as it is, that the schools in the development of programs for the superior student in the public schools should be guided by the principle: *Efforts must be made or increased which will emphasize those activities which will strengthen a spectrum of traits called Self-Evaluating* (Intellectual Curiosity and Persistence).

This is not to say that efforts in the direction of selecting and encouraging superior students should be lessened. For example, Nason in a study of 237 superior high school students identified a pattern of traits which appeared to distinguish between high and low achievement students. "A pupil with this pattern was described as being satisfactorily adjusted; he planned to go to college, he had a fairly specific future vocational plan, and recognized either an inspiration or a source of encouragement."[4] Nason also indicated that the pattern of circumstances did not completely account for academic achievement or lack of it. This suggests a missing key to the pattern which might well be the self-evaluating items in this study or the persistence-questing spectrum of traits described by Brandwein.[5] These may constitute what so many writers have termed motivation or to state it differently: What values do superior students set on achievement?[6] Perhaps of most importance is an increased emphasis, or a return to, an intellectual climate in the public schools and colleges too, especially for the superior student. High achievement and performance for all students, but primarily for superior students, may be likened to a three-legged stool having genetic, activating, and persistence-questing legs.[7] Any program for the superior student that does not possess these three supports, is likely to be floored. College and university programs aimed at these supports in cooperation with the public schools cannot help but quicken the pace for the superior student.

[4] Leslie J. Nason, *Academic Achievement of Gifted High School Students*. University of Southern California Press, Los Angeles, 1958. p. 67.

[5] Paul F. Brandwein, *op. cit.*, pp. 9–12.

[6] Robert F. DeHaan and Robert J. Havighurst, *Educating Gifted Children*. The University of Chicago Press, 1957. p. 135.

[7] Paul F. Brandwein, *op. cit.*, pp. 9–12.

SALT WATER CAN PRODUCE CROPS

Brackish water can be used for crop production if it is one-tenth to one-eighth as salty as seawater. Thus, many crops can be saved during droughts by irrigation with brackish water in coastal areas where the sea has flooded into surface water sources or infiltrated wells. Growers wishing to make safe and effective use of salt water should make arrangements for analysis of the salt content through their county agricultural agents or Soil Conservation Service, the U. S. Department of Agriculture here reports.

Socialized Multiplication—A Reply*

John C. Bryan
State Teachers College, Cortland, New York

According to H. C. Christofferson,[1] the science teacher and textbook writer are seeking a way by which they can multiply two concrete quantities without writing new rules of multiplication. This article is an attempt to define the operation in a manner which is satisfactory to the physics teacher and the mathematician.

Robert Swain[2] distinguishes between the different units of measure; "basic" measures, such as distance, and "derived" measures, such as velocity. All numbers, except the digits, are derived in some fashion, and measures are certainly man-made contrivances, so it is justifiable to use these "derived" measures. It is required, however, that they satisfy a set of postulates, particularly that set which is used with the real number field.

The postulates of the real number field include two postulates of multiplication which are applicable to this problem. These postulates are commutativity, $a\times b=b\times a$, and associativity,

$$a\times(b\times c)=(a\times b)\times c.$$

To the set of postulates are added some definitions of concrete quantities and it is possible to develop a rigorous "socialized multiplication."

The first definition is based on the usual process of multiplying a concrete quantity by an abstract number, ie., 3×4 ft. = 12 ft. If this is an acceptable extension of multiplication, it is permissible to define a concrete quantity as the product of an abstract number and a concrete unit, i.e., 6 ft. = 6×1 ft. Thus, concrete quantities are expressions similar to the algebraic expressions $2a$ and $7y^2$.

* EDITOR'S NOTE: This article, like the one by Rappaport on p. 202 of this issue, was stimulated by Christofferson's article that appeared on pp. 532–9, in the October 1959 issue of SCHOOL SCIENCE AND MATHEMATICS, Mr. Bryan's article was submitted to Mr. Christofferson prior to publication. A portion of Christofferson's reply is quoted here:

"Thanks very much for letting me read Mr. Bryan's response to my article in the October issue of SCHOOL SCIENCE AND MATHEMATICS. This sort of reaction is what I had hoped for. I trust that there will be other responses and other suggestions for the solution of this problem.

In my opinion Mr. Bryan has an excellent solution. However, when he defines one square foot as 1 ft.$\times$1 ft. or one foot multiplied by one foot instead of "a unit of area that is square and one foot on a side," or "a unit of area that is square and one foot by one foot" then he really accepts my definition of multiplication. If 1 ft.$\times$1 ft. equals 1 square foot by definition, then 2 ft.$\times$3 ft. = 6 sq. ft. by the same definition. The shifting by the use of the various manipulative laws does not change this fact, in my opinion. I believe that Mr. Bryan and I are in essential agreement in that we believe that by definition or by some sort of postulation or agreement of some kind that we should be permitted to say that 1 ft.$\times$1 ft. = 1 sq. ft. and 10 men$\times$6 hours = 60 man hours and all sorts of multiplications of this kind."

The editors of SCHOOL SCIENCE AND MATHEMATICS are pleased by such professional reactions.—GGM

[1] Christofferson, H. C., "Multiplication Socialized," SCHOOL SCIENCE AND MATHEMATICS, 59: 532–539, October, 1959.

[2] Swain, Robert, *Understanding Arithmetic*, Rinehart, 1957, p. 199.

The "derived" measures can be defined as products of the "basic" measures as follows:

$$1 \text{ sq. ft.} = 1 \text{ ft.} \times 1 \text{ ft.}$$

$$1 \text{ mph} = 1 \text{ mi.}/1 \text{ hr.}$$

$$1 \text{ cu. in.} = 1 \text{ in.} \times 1 \text{ in.} \times 1 \text{ in.}$$

$$1 \text{ ft.-lb.} = 1 \text{ ft.} \times 1 \text{ lb.}$$

Other "derived" measures can be defined in the same manner. There is no limit to the type or number of these measures.

By using the postulates of the real numbers and the definitions of the "derived" measures, the physics teacher should be able to do the "dimensional analysis" with full faith in the results.

As the first example, take a problem in the computation of area, such as, to find the area of a rectangle 8 inches long and 3 inches wide. According to the definition of concrete quantities above, the problem may be stated as:

$$8 \text{ in.} \times 3 \text{ in.} = (8 \times 1 \text{ in.}) \times (3 \times 1 \text{ in.}).$$

By associativity,

$$(8 \times 1 \text{ in.}) \times (3 \times 1 \text{ in.}) = 8 \times (1 \text{ in.} \times 3) \times 1 \text{ in.}$$

By commutativity,

$$8 \times (1 \text{ in.} \times 3) \times 1 \text{ in.} = 8 \times (3 \times 1 \text{ in.}) \times 1 \text{ in.}$$

By associativity,

$$8 \times (3 \times 1 \text{ in.}) \times 1 \text{ in.} = (8 \times 3) \times (1 \text{ in.} \times 1 \text{ in.}).$$

In this form, the definitions of the multiplication of real numbers provide the solution of 8×3, and the definition, $1 \text{ sq. in.} = 1 \text{ in.} \times 1 \text{ in.}$, permits the substitution of a new measure.

By substitution,

$$(8 \times 3) \times (1 \text{ in.} \times 1 \text{ in.}) = 24 \times 1 \text{ sq. in.}$$

By using the definition of concrete quantities,

$$24 \times 1 \text{ sq. in.} = 24 \text{ sq. in.}$$

A second example could be to find the work required to lift a weight of 3 grams to a height of 6 centimeters. The procedure would be as follows:

Definition 1: $3 \text{ g.} = 3 \times 1 \text{ g.}$

Definition 2: $1 \text{ g.-cm.} = 1 \text{ g.} \times 1 \text{ cm.}$

Step 1: $3 \text{ g.} \times 6 \text{ cm.} = (3 \times 1 \text{ g.}) \times (6 \times 1 \text{ cm.})$ (Definition 1)

Step 2:	$=3\times(1\text{ g.}\times 6)\times 1\text{ cm.}$	(Associativity)
Step 3:	$=3\times(6\times 1\text{ g.})\times 1\text{ cm.}$	(Commutativity)
Step 4:	$=(3\times 6)\times(1\text{ g.}\times 1\text{ cm.})$	(Associativity)
Step 5:	$=18\times 1\text{ g.-cm.}$	(Definition 2)
Step 6:	$=18\text{ g.-cm.}$	(Definition 1)

This procedure can be extended to problems involving ratios, such as, velocity, acceleration, price per unit measure, etc. The postulates of multiplication as applied to rational numbers yield

$$\frac{a}{b}\times\frac{c}{d}=\frac{a\times c}{b\times d}\,.$$

This definition suggests a method for the solution of problems involving the ratio or quotient of two concrete quantities.

An example, to find the velocity required to travel 180 miles within a 3 hour period, will illustrate the use of this definition.

Definition 3: 1 mph = 1 mi./1 hr.

Step 1:	$v=s/t=180\text{ mi.}/3\text{ hr.}$	(Definition of velocity)
Step 2:	$=\dfrac{180\times 1\text{ mi.}}{3\times 1\text{ hr.}}$	(Definition of a concrete quantity)
Step 3:	$=\dfrac{180}{3}\times\dfrac{1\text{ mi.}}{1\text{ hr.}}$	(Definition of multiplication of rational numbers)
Step 4:	$=60\times 1\text{ mph}$	(Definition 3)
Step 5:	$=60\text{ mph}$	(Definition of a concrete quantity)

Although this method requires definitions for the new units of measure, they are inherent in the definitions from the science in which they originate. No other changes are needed in the postulates of the real number field.

It is understood that this method is too precise for constant use, just as the postulational method of doing arithmetic would be burdensome. The method provides a justification for the physics teacher's "dimensional analysis" so that he may proceed with his teaching.

A new comet bright enough to be seen with binoculars has been discovered low in the southeast sky.

Of eighth magnitude, the comet was spotted in the constellation of Libra, the scales, which is visible from the United States near the southeast horizon shortly before sunrise. The diffuse stellar object, which has a short tail, will be known as Comet Mrkos after its discoverer, Antoin Mrkos of the Astronomical Observatory at Skalnate Pleso, Czechoslovakia.

Units in Measurement Should Be Meaningful

David Rappaport
Chicago Teachers College, Chicago, Illinois

The application of mathematical processes and concepts to concrete situations has created some problems for teachers who attempt to teach arithmetic meaningfully. Christofferson[1] has written a very stimulating article on the interpretation of multiplication when the multiplier and the multiplicand are both concrete or denominate numbers. He argues that the mathematicians' limiting definition of multiplication acts as a barrier to its effective application to problems in science. He offers three types of examples of abstract and concrete, or socialized, multiplication that illustrate the three situations in a social setting that require multiplication for its solution.

1. The multiplier and multiplicand are both abstract.

$$3\times 5=15, \text{ means } 5+5+5=15$$

2. The multiplier is abstract and the multiplicand is concrete.

$$3\times 5 \text{ ft.}=15 \text{ ft., means } 5 \text{ ft.}+5 \text{ ft.}+5 \text{ ft.}$$

3. The multiplier and multiplicand are both concrete.

$$3 \text{ ft.}\times 5 \text{ ft.}=15 \text{ sq. ft.}$$

Whereas the mathematicians accept the first two meanings, they do not generally accept the third. Christofferson believes that the acceptance of the third meaning of multiplication would eliminate confusion and errors in its application to physics, chemistry, business, etc.

The important issue raised by Christofferson is not the meaning of multiplication but the meaning of units in measurement. It is true that physicists accept the meaning of pounds times feet, but it is also true that many students may have given up further study of physics because they did not understand the meanings implied in a physics problem and were forced to solve exercises by mechanical processes. The meanings of measurement units must be understood and both *mathematics teachers* and *physics teachers* should teach measurement in a meaningful way.

If it is true that 5 lbs.$\times$3 ft.=15 ft. lbs., is it also true that:

1. 5 men$\times$3 dollars=15 man dollars,
2. 5 children$\times$3 dollars=15 children dollars, and
3. 5 pigs$\times$3 pigs=15 sq. pigs?

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[1] H. C. Christofferson, "Multiplication Socialized," SCHOOL SCIENCE AND MATHEMATICS, 59: 532–539, October, 1959.

Indiscriminate multiplication of concrete numbers, as advocated by Christofferson, would result in more confusion and less understanding. This would be a step backward and would undo the progress made during the last twenty years in making arithmetic more meaningful to children.

The widespread interpretation of the formula $A = bh$ as the area of a rectangle equals the product of the base and the height is incorrect and confusing. A does not stand for the area, b does not stand for the base, and h does not stand for the height. A, b, and h stand for numbers.

Take the following example: What is the area of a rectangle whose base is 5 ft. and whose height is 3 ft.? The question is, how many units of area does this rectangle contain? The unit of area is a square foot. The child may answer the question by counting the number of

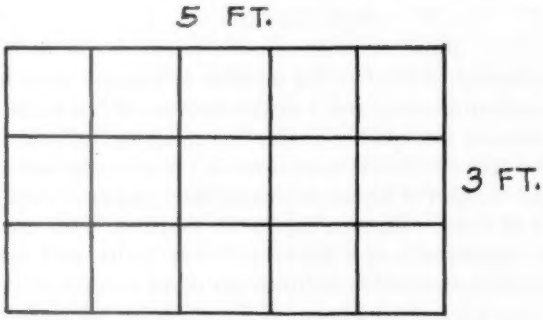

FIG. 1

squares in the rectangle. He may shorten his work if he notices that there are 3 squares in each column and that there are 5 columns. He therefore reasons that he has 5 groups of 3 squares or 15 squares altogether. In the formula $A = bh$, the A represents the number of squares, b the number of columns, and h the number of squares in one column. It is true that there is a one-to-one correspondence between the number of columns and the number of feet in the length of the rectangle. It is also true that there is a one-to-one correspondence between the number of squares in one column and the number of feet in the width of the rectangle.

The area of the rectangle can also be interpreted as $A = hb$, where h stands for the number of rows and b stands for the number of squares in one row. The fact that there is a one-to-one correspondence between the number of squares and the number of linear units in the length or the width does not mean that one may substitute feet for square feet.

The formula $V = lwh$ should not be interpreted as the volume of a rectangular solid is equal to the length times the width times the height. Here we are asked to find the number of units of volume, which are cubic units.

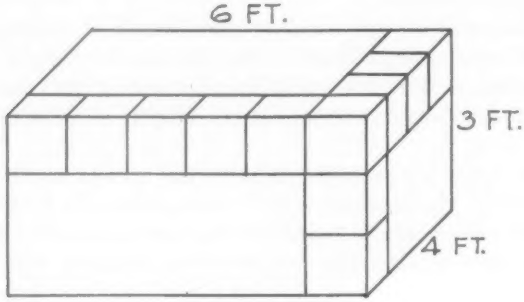

FIG. 2

We may interpret the l as the number of volume units in one row, w as the number of rows, and h as the number of layers. It is possible to make different interpretations by changing the formula to $V = wlh$, $V = lhw$, $V = hlw$, etc. In all cases there is a one-to-one correspondence between the number of linear units and the number of cubes in a row, or number of rows, columns, layers, or sections. The existence of a one-to-one correspondence between linear units and groups does not justify the substitution of linear units for groups.

In the examples cited above, if 5 men have $3 each we do not multiply $3 by 5 mean in order to find how many dollars there are altogether. There is a one-to-one correspondence between the number of groups and the number of men, or the number of children. There is no unit called man dollars or child dollars. We do not multiply pigs by pigs and get square pigs, because there is no unit called square pigs.

If we apply the formula $A = bh$ in the following manner, (Fig. 1) $A = 5$ ft.$\times 3$ ft. we really have 5×1 ft.$\times 3\times 1$ ft. which equals $5\times 3\times 1$ ft.$\times 1$ ft., or $15-1$ ft.$\times 1$ ft. It is necessary here to interpret 1 ft.$\times 1$ ft., not as 1 ft. times 1 ft., but as 1 ft. by 1 ft. Since we interpret 1 ft. by 1 ft. as a unit 1 sq. ft. we can then interpret the answer as 15 sq.ft.

If $l = 6$ ft., $w = 4$ ft., and $h = 3$ ft. (Fig. 2) one may interpret $V = lwh$ as $V = 6$ ft.$\times 4$ ft.$\times 3$ ft.$= 6\times 1$ ft.$\times 4\times 1$ ft.$\times 3\times 1$ ft.$= 72-1$ ft.$\times 1$ ft.$\times 1$ft.$= 72$ cu. ft. only if one understands that 1 ft.$\times 1$ ft.$\times 1$ ft. is not 1 ft. times 1 ft. times 1 ft., but 1 ft. by 1 ft. by 1 ft. or 1 cu. ft.

Christofferson writes:

Handling the unit names like letters in algebra or like numbers makes for less error and greater simplicity. Note its use in the formulas:

$$S = Vt \quad \text{or}$$

$$S = Vt = \frac{20 \text{ ft.}}{1 \text{ sec.}} \times 10 \text{ sec.} = 200 \text{ ft.}$$

Dividing out the unit 1 sec., like one would divide or "cancel" out any other factors, works perfectly.[3]

Of course it works perfectly, but only in the sense that one derives the correct answer. Can the student who does this explain what it means? This is a good example of mechanical processes that have been used in the past and which were not effective because there was little understanding. The more complicated the formula, (the more measurement units and processes involved), the more mechanical the process of solution and the less understanding of meanings result.

The units used in physics are not always clear to the beginning student. It is true that a foot-pound is the unit for measuring work, but does this mean that feet are multiplied by pounds? How much work is required to lift 5 pounds to a height of 10 feet? The formula is $W = m \times d$ or $W = 5$ lb.$\times 10$ ft. An analysis of the situation shows that we have 5×1 lb.$\times 10 \times 1$ ft. or $5 \times 10 \times 1$ ft.$\times 1$ lb., or 50 ft. lb. Here the unit is 1 ft. lb. or 1 ft.$\times 1$ lb. The $\times$ could be replaced by a hyphen—so that we could read it as 50 ft.-lb.

The unit in acceleration is feet per second per second. But what does this mean? Writing it as ft./sec.^{2} does not explain nor clarify the unit. What is the meaning of seconds squared? The formula $F = ma$ must be understood before it can be applied. Following Christofferson's suggestion the student would substitute in the formula as follows:

$$F = 10 \text{ lb.} \times \frac{4 \text{ ft.}}{\text{sec.}^2} = 40 \frac{\text{ft. lb.}}{\text{sec.}^2} \cdot$$

Does the student understand what he is doing and can he interpret the results? This writer feels that too many physics students do not understand the meanings of the answers they get in physics exercises. Many students merely follow instructions, substitute in formulas, write the answers, puzzle over the answers, until they reach a point where they can no longer cope with the situation and give up the study of physics.

When the units are understood and the main concern is getting the answer, then it may be permissible to use mechanical processes. The student should know the meanings of the units that define work, force, energy, and momentum before he should be asked to work exercises that involve such units.

Mathematics and science teachers should teach the meanings of units so that the children will develop a better understanding of the

[3] *Op. cit.*, p. 535.

social situations that involve application of mathematical processes to such problems and will be motivated and encouraged to pursue further study in mathematics and science. Understanding rather than "drill" should be the goal for problem solving in concrete or social mathematics as well as in abstract mathematics.

SPACE RESEARCH CENTER TO PROBE JUPITER'S AIR

The world's largest radar antenna soon to be built in Puerto Rico will be used to probe the surface of the planet Jupiter.

If radar signals are reflected by Jupiter, U. S. scientists expect to gather new information about the planet's surface. If no signals are reflected, scientists will know for the first time that this largest of the outer planets is shrouded in a deep atmosphere that absorbs radio waves.

The giant radar, to be the biggest in the world, is being financed by the Department of Defense and will be used by Cornell University's new Center for Radiophysics and Space Research.

The radar is to have a 1,000-foot receiving dish nestled in a natural bowl of coral limestone. This antenna is four times larger than Britain's powerful Jodrell Bank unit which now holds the record for contacting Venus.

The Cornell-designed radar unit it to be able to probe at distances of 400,000,000 miles. It will operate on a peak power of 2,500,000 watts and a frequency near 420 megacycles a second. The finger-like radar beam will be able to sweep 20 degrees in each direction, and may shed new knowledge on the earth's own ionosphere. In addition, the radar will be able to bounce signals from the moon, Venus, Mars, Mercury and the sun.

WHOLE CELL DETERMINES BEHAVIOR AND INHERITANCE

The nucleus, the so-called "brain" of a cell, with its genes, can no longer be thought of as the sole determiner of what makes a cell behave as it does or what it will do in future generations.

There is a marvelous system of give and take between the genes and the cytoplasm, or non-nuclear material. Researchers are turning up more and more evidence that the gene-carrying chromosomes are profoundly influenced by their exact location within the cell.

This give and take can explain how body cells with the same chromosomes can can be as different as a skin cell, a nerve cell or a bone cell. It also points to a revolution in genetics that is now in full swing.

There is no longer any doubt that the same set of chromosomes shows differences in appearance in different kinds of cells. These differences may indicate differential activity of the chromosomes and genes. There are several examples of these differences. For instance, one particular chromosome in certain tumor cells looks very different from the same chromosome in normal cells. Also, many kinds of cells in female mammals, including human, show a chromosomal structure not found in the same male cells. Furthermore, this structure is found only in certain kinds of cells.

Some genes may be working all the time. Others have their activity limited by cytoplasmic substances that are themselves formed by the action of controlling genes.

There is one part of the chromosome that may prove to be of supreme importace for gene action in cell differentiation. This is a part called the "H" part. The "H" part or parts contain very few genes.

Researchers studying corn and fruit flies have found that these parts or regions of the chromosomes have strong controlling influences on nearby genes.

Earth and Space Science in the K-12 Science Program*

Loren T. Caldwell

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An increasing number of the nation's school curriculum planning groups are recognizing that the K-12 science programs need restudy, and reorganization in order to better meet present curricular needs. When the student's entire school day is considered, much too little time is spent with science learning from grades K-9. It appears to this writer that our best science programs in operation now, for grades K-6, consist largely of learning to recognize a few selected, unrelated scientific phenomena which are found in natural order about us. Many current science programs for grades 7–9 exist with widely diverse objectives and educational functions. These science learning experiences are largely an extension of learning to recognize and formally classify scientific phenomena during the 7–9 grades. In grades 7, 8, and 9 it is logical to expect the junior high school students are ready to organize and to correlate science facts and to recognize basic scientific principles as deductions from these correlated facts. Even though this may have been the plan in the curriculum outline for many school systems, most junior high school science teachers have not found it possible to make such correlations nor to convince students of the truth possessed by those scientific laws and principles which were studied. The learning experiences in the sciences for 7, 8, and 9th in the past several years have too often consisted of units restudied to recognize and classify natural and industrial scientific phenomena. Therefore, it is apparent that many science programs found in grades K-12 need some major reevaluations and reorganization particularly in the 7 through 9th grades.

All concepts of science in the junior high school should start to be semi-quantitative, since students on these academic levels have the maturity for a serious start in the quantitative evaluation of our universe, its natural phenomena, natural laws of inanimate behavior, and basic scientific principles. This semi-quantitative approach would be one dealing with relative values, expressed in ratios and proportions. Semi-quantitative aspects of all the sciences might guide scientific learning objectives in the junior high school, toward more exact and specific quantitative evaluations of scientific concepts to be included in the senior high school.

If the science curriculum of the 7, 8, and 9th grades is to be upgraded two or more years as compared with past practices, the 7th and 8th grades science program should deal with the semi-quantita-

* Paper presented at the Meeting of the Science Teaching Societies affiliated with the AAAS, Chicago, Illinois, December 28, 1959.

tive aspects of our natural phenomena and laws of physics and chemistry. These learning units might be referred to as a revision of many units in the present 9th grade general science outline of study. These new science units in the 7 and 8 grades should be paralleled by appropriate preparation in the basic concepts of mathematics. These concepts could be selected from the present outline of arithmetic, plane and solid geometry, and algebra. The academic intent of this kind of mathematics would be to serve the student in his search for the semi-quantitative understandings to be made in a study of the natural and industrial phenomena involving basic laws in physics and chemistry.

If the above program were realized for the 7th and 8th grades, than an adequate and effective program of learning experiences could be offered from the Earth Sciences for the ninth grade science program. The concepts secured from units in mathematics, physics and chemistry for the 7th and 8th grades would prepare the ninth grade student to understand the complex interrelationships of natural forces found in the study of the earth's rocks, atmosphere, oceans and space. In placing the Earth Sciences in the ninth grade, a foundation could be laid for a more comprehensive understanding of learning experiences for the tenth grade to be taken from the large cultural area of ecological biology. All of those cause-and-effect science concepts to be studied during the 7, 8, and 9th grades, should produce a tenth grade student capable of appreciating, and understanding the very involved set of forces at play in any average bio-ecological situation.

Results from a survey of state courses-of-study for the sciences in grades K-12 which has been secured by this writer from many of the State Offices of Public Instruction in the U. S. reveal that some state offices of Public Instruction and many large-city offices of Public Instruction are planning to revise or have already revised their grades K-12 science programs. A few of these offices of Public Instruction have already completed these revisions in their science programs and some have published their new Courses-of-Study and Teacher Guides. I find it appropriate to report the results of this survey relative to the place of the Earth and Space Sciences in these K-12 Science programs.

Six of the states have reported with recommendations to their school districts including teacher guides and course outlines in Earth and Space Science for the ninth grade. Three other states have reported that these state-wide curriculum guides now being formulated will probably include course outlines for Earth and Space Science which might be offered in grades 9–12.

Three additional states report an interest in the organization of

Earth and Space Science units into a separate course but are frankly in need of some additional encouragement from well-known academic circles. Teacher certification requirements for Earth and Space Science teachers are formulated by only those states with specific Teacher Guides and Course Outlines now published and distributed to their school systems.

In a "science letter" of March 1949 and several subsequent letters, the New York State Education Department described an experiment designed to take care of individual differences as far as science interests and aptitudes are concerned. The experiment was to place ninth year students "selected on the basis of drive, interest, aptitude and previous performance in science," in an Earth Science class. In the past 10 years this program has grown to the point where there are about 350 ninth year Earth Science classes in about 250 New York State Secondary Schools. Only favorable criticisms of the plan throughout the State during the 10 years the program has been in effect have been received.

Connecticut's State Dept. of Education Sci. Ed. Curr. Bull. #XII writes as follows: "It can be assumed because of increased attention of science in the elementary schools, that pupils will enter grade seven with considerable formal knowledge of science, and with some understanding of certain basic scientific principles. . . . " It is recommended in this bulletin that the science program for grades 7 and 8 be organized as a single course covering two years. It would be the purpose of this course—to build semi-quantitative concepts, facts, and an understanding of many scientific principles founded in the earlier grades. It further states that an important purpose of science in grades 7 and 8 is the identification of those pupils with good and superior science abilities. . . . "

This bulletin also indicated that by the end of the grade 8, it should be possible to group students according to their interests and abilities in science. Categories into which students may be grouped are: 1. *Terminal students*, 2. *College preparatory*, 3. *Talented students*, and 4. *Vocational students*.

A diagram of the science program proposed by this state is given in the figure shown below. Here Earth Science is recommended for the ninth year in three of the four curricula and in the fourth curricula a combination of biology and/or earth science is recommended for the vocational sequence in the ninth year to be followed by the technological phases of physics and chemistry during the 10, 11, and 12 grades.

Earth Science is commonly defined as including elements of physical geography, geology, astronomy, meteorology, oceanography, space science and the scientific aspects of conservation. Each of

DIAGRAM OF THE SCIENCE PROGRAM GRADES 7–12

Grade 7 → General Science*
Grade 8 → General Science*

	Terminal Sequence	College Prep Sequence	Talented Sequence	Vocational Sequence
Grade 9	Earth Sci.	Earth Sci.	Earth Sci.	Earth & Bi. Sci.
Grade 10	Biology	Biology	Biology	Related Sci.
Grade 11	Physical Sci.	Chemistry	Chemistry	(Tech. Physics & Chem.)
	↓ or	↓	↓	
Grade 12	Physical Sci.	Physics	Physics Adv. Sci.	

* All students should be required to take General Science in grades 7 and 8. It is recommended that all students take a minimum of two years of science in grades 9–12 and one year in grades 11 and 12.

these areas is developing rapidly and is assuming economic importance akin to that of Biology, Chemistry, and Physics. To quote again from the Curriculum Bulletin Series #XII, State Department of Education in Hartford, Conn. Science Education, page 9, "The importance of Earth Science today indicates that it deserves a place in the high school science program—there is ample evidence that it can be effectively studied by 9th grade students."

Bulletin #XII (tentative) also states that: "Earth Science deals with an area of science which has long been neglected in most high school science programs. Now however, Earth Science is emerging as an area of science with great and rapidly growing economic importance. Thus it is becoming as worthy of a place in the high school program as Biology, Chemistry, and Physics. Earth Science is an appropriate first course in a sequence of specialized sciences courses. It can be of large personal and cultural value in developing understanding about the physical world and of outer space. The study of Earth Science involves principles and techniques that are of basic importance in other sciences such as advanced quantitative physics, chemistry, and biology."

In the ninth grade Earth Science course, it is important that each topic studied, represents a deepening and broadening of the scientific understandings acquired in earlier grades. To avoid unnecessary repetition, it is essential that the understandings which students bring with them into the Earth Science course be used as a base for the interpretation of the scientific nature of the physical, chemical, biological and atomic universe. After such learnings have been real-

ized, the student can best appreciate the need for specialized studies in the areas of advanced earth science, biology, chemistry, physics, and the space sciences.

In regard to the grade placement for a year of Earth Science in the grades K-12 science curriculum, permit me to quote from issues of *Curriculum Highlights*, Dept. of Instruction, Commonwealth of Pennsylvania, for Sept. 1958, June 1959, and July 1959. In Sept. of 1958, the New Curriculum Requirements provided by the State Council of Education Action "In the area of elementary and junior high school science, the Council acted to provide for continuous instruction in science for all students from kindergarten through grade nine. At the elementary level a planned sequence of science experiences appropriate to the grade level shall be included in the elementary curriculum beginning with kindergarten and extending through grade six."

This publication also indicated that at the junior high school level science shall be required for all students in grades seven, eight, and nine. Significant changes in the teachings of mathematics and science can be expected in the next few years. They will appear both in study requirements for pupils and in course content. "In the junior high school the arithmetic in the seven and eight grades is being more intensified for the more able pupils so that more algebra may be studied in the eighth grade. Science is now required in ninth grade."

In the June 1959 issue of the Newsletter, Dept. of Instruction, Commonwealth of Pennsylvania, the Department of Instruction describes Earth and Space Science grade placement. "The Earth and Space Science study outline in preparation for October 1959 is planned to be both comprehensive and of an advanced character. The latter characteristic of the outline supports the unanimous opinion of the committee on curriculum producing the guide that since the content of the course needs to be tailored to several interest and ability levels it is desirable to have a study outline which is comprehensive and advanced. It is so much easier for a teacher to abbreviate and 'tone down' the offering than to extend and upgrade the content, if the study guide were built upon mediocre standards."

It was further urged in the Newsletter that the content of the usual ninth grade general science courses be covered by a strong science program in the grades eight and below. This leaves the ninth grade science available for either biology or earth and space science.

If biology is offered in grade nine an earth and space science course should be offered in grade 10, 11, or 12 aimed at the needs of students desiring to specialize in geology, astronomy, meteorology or related areas.

The Committee on Curriculum indicated in this same Newsletter that school districts desiring to offer the earth and space science course mainly for general education purposes should offer it in grade nine to all pupils. If feasible, it may be offered to the exceptionally gifted students in grade eight.

This same curriculum Newsletter reports on Earth and Space Science Teacher Certification, "There is no certification regulation for Earth Science at the present time. Teachers certificated in Physical Sciences, and/or Geography may teach Earth and Space Science until 1963, at which time the new regulations will go into effect. Teachers having 24 semester hours in Earth and Space Science may be certificated to teach in this area beginning October 1, 1963."

The place of the Earth Sciences in the Grades K-12 science program is truly an academic one. The academic purpose of the science program is to acquaint the science student with the nature of our environment in all of the scientific respects. With an appreciation of the basic concepts of mathematics, physics, chemistry, and biology in the mind of the student, from earlier grades, a study of the true nature of the Earth and of Space can be undertaken in the ninth grade. This Earth and Space Science study can best be understood if study units are arranged in their natural sequence. Such a sequence follows the events of cosmic, geologic, and biologic history. In such a sequence, any teacher may find guidance for the organization of the study outline to be followed during a year of ninth grade Earth and Space Science.

When the Space and Earth Sciences are organized upon a natural course-of-event sequence, their relations and casual significances can best be learned by any one studying this phase of our culture. Such an organization of scientific ideas is also a difficulty-of-learning sequence where each learning experience helps the student to understand the following learning experiences on its highest levels of cause, effect, and value judgment. To give specific meaning to this sequence, permit me to list a few topics organized with this sequential organization.

1. Origin of elements in space.
2. Distribution and Motions of Matter in Space.
3. Relation of the Solar System's Origin to Space Matter.
4. Specific origin of the earth in the formation of the solar system.
5. Physical, chemical, and biological changes resulting during geologic history.
6. Development of present landforms on the earth.
7. History and present nature of the earth's atmosphere.
8. Weather and climate and their associated phenomena in the atmosphere.
9. History and present nature of the earth's oceans.
10. Relations between oceans and the atmosphere.
11. Physical, Chemical, and Biological activities within the oceans.
12. Rock and minerals of economic importance from the earth.

13. Land surface water and ground water supply audit.
14. Scientific controls on the resources management practices.
15. Space environments in space travel.
16. Astronomical force and motion aspects in space travel.

These sixteen topics could be the centers-of-interest about which 36 weeks of classroom discussion and laboratory activities might center. If the education of the teacher, student release time, and the material facilities of the school were adequate for the effective study of the above named topics much academic value should be derived from their study.

The writer feels confident that a year of study in the Space and Earth Sciences during the ninth grade in the grades K-12 Science program could help the Senior high school student to more accurately decide whether some one of the many sciences should become his or her academic area of specialization. Also all students could see the relationship between good citizenship and knowledge of the sciences. The study of Space and Earth Science as a terminal curriculum would open the door to many students for hobby interests which might aid mental hygiene. Finally all students of Earth and Space Science could better learn to see our human culture as a single scientific whole and as a result give specific meanings to the social implications of scientific facts.

MAGNETISM AIDS MAN IN WAR AGAINST DISEASE

Magnetic forces are healing some of man's ailments.

Magnetism is being used by researchers to direct healing chemicals to a particular part of the body. These chemical particles are known as alpha iron crystals. They have the ability to pass through the tiniest capillaries of the body.

These iron crystals actually carry itotopic radiation or some adsorbed healing chemical throughout the body. The crystals can be alloyed with the properly selected radioactive element, or coated with an adsorbed layer of a therapeutic agent, Dr. Freeman said.

The first patient to receive alpha iron particles, was a six year old boy suffering from idiopathic thrombocytopenic purpura, a disease characterized by hemorrhages, purple patches on the skin and a reduction in the number of blood platelets.

He was given iron crystals which he absorbed under his tongue. Within 10 minutes after each such treatment, the serum iron in the boy's blood increased by 70%.

While the researchers do not pretend to understand fully the reasons for this reaction, they suggest that it may be connected with blood kinetics and enzyme activity.

It had been shown earlier that mice, when subjected to a magnetic field of from 3,000 to 6,000 gauss for from one to four weeks, experienced a decrease in white blood cells. When removed from this environment, however, their white cell count jumped more than 70% normal values.

This effect has been used to reduce the death rate due to cancer from cobalt radiation.

Proposed Revision and Acceleration of the High School Mathematics Program*

Curriculum Department

Madison Public Schools, Madison, Wisconsin, August, 1959

During the summer of 1957 a committee of high school mathematics teachers was formed to revise the mathematics curriculum in senior high school. The primary objective of this committee was the preparation of an accelerated mathematics program for gifted students. It was felt that a course on the college level could be offered to these students in their senior year as a means of obtaining college credit and/or advanced placement. This credit or advanced placement could be acquired either by prearrangement with the University of Wisconsin or by taking the examinations of individual colleges or the College Entrance Examination Board.

A second objective of the committee was the general revision and modernization of the mathematics curriculum. It has been apparent for several years that our existing program has included many antiquated topics, methods and texts. In order to meet the current needs of all high school students wanting extensive training in mathematics, many changes had to be made. With these thoughts in mind the committee developed an initial program which, by continuous revision, will best meet the needs of our students. Discussion and revision of this initial program has taken place during the summers of 1958 and 1959. The following is a summary of the committee's work during the past three years.

The 1956–57 high school mathematics program consisted essentially of three tracks:

	Track		
	I	II	III
9th	Algebra	Algebra	General Mathematics
10th	Plane Geometry	Plane Geometry	
11th	Advanced Algebra Solid Geometry		
12th	College Algebra Trigonometry		

* Paper presented by Donald G. McCloskey at the Annual CASMT Convention, Chicago, Illinois, November 26–28, 1959.

Track I was primarily for those students who wanted a thorough mathematics preparation for college work, while Track II was required of most students and was sufficient to meet the college entrance requirements. Track III was for students who needed more work in arithmetic and general mathematics and did not meet college requirements. It was the Track I students with whom we were primarily concerned, but some of the proposed changes also required minor changes in Track II. If a student met all the requirements of Track I, he usually qualified for a course in analytic geometry and calculus in his first semester of college. However, many colleges including the University of Wisconsin now expect the engineering or science student to enter college with this type of preparation. Therefore, if we intend to offer a course which will give the exceptional student a "head start," and for which colleges will consider giving credit, we have to offer analytic geometry and calculus.

In order to give the exceptional student the above mentioned "head start," the final plan selected offers algebra in the eighth grade, followed by a sequence of courses leading to calculus in the twelfth grade. The first group of eighth grade students will begin algebra during the school year 1959–60.

We also felt it was necessary to revise several existing courses. The main change required was as follows: keep only a minimum of solid geometry, and combine it with the course in plane geometry. This affected Track I as well as Track II, but the changes were minimal, and the student in Track II profited because he had the opportunity to learn some solid geometry.

To provide for the exceptional students currently enrolled in grades eight through ten, who did not have the opportunity to take algebra in the eighth grade, the following four year interim program has been adopted:

	Track Ia (Advanced Program)	Track Ib (Normal Program)
9th	Algebra	Algebra
10th	Plane and Solid Geometry	Plane and Solid Geometry
11th	College Algebra and Trigonometry	Advanced algebra and Trigonometry
12th	Topics in Algebra Analytic Geometry and Calculus	College Algebra and Analytic Geometry

This program will remain in effect until the school year 1962–63 when the following sequence will become fully operative.

	Track I (Advanced Program)	Track II (Normal Program)
8th	Algebra	Arithmetic
9th	Geometry	Algebra
10th	Advanced Algebra and Trigonometry	Geometry
11th	College Algebra and Analytic Geometry	Advanced Algebra and Trigonometry
12th	Calculus	College Algebra and Analytic Geometry

Track I is for the accelerated student, while Track II is for the average student and is the same as our interim program Ib.

There are several advantages to the preceding plan. First, if a student shows a high aptitude very early, his mathematics program can be accelerated by following Track I which essentially steps up each course one year. In the interim program, a sharp acceleration comes primarily in the junior year and is more difficult for the student to handle; while in the above plan the acceleration is more "change in subject matter" at the eighth grade level than "speeding up."

Second, the two tracks above involve the same courses, except for the senior calculus course in Track I, and should therefore be easier to administrate. Third, it is the opinion of the committee that more of the capable students will follow the program starting with algebra in the eighth grade, and we will have more students who can take an advanced course. Outstanding students in Track II, who for some reason may not have been placed in the accelerated program earlier, may transfer to Track I at the end of the tenth grade. It will be necessary for these students to take a semester of trigonometry in addition to the college algebra and analytic geometry in the eleventh grade. These students will follow Track Is (see chart) which merely uses part of both Tracks I and II. It is anticipated that the number of students transfering from Track II to Track I will be relatively small.

At the present time we feel that the accelerated sequence outlined above is the most desirable solution, but because of the program's experimental nature we feel that constant study and revision will be necessary.

The following chart illustrates diagrammatically the various courses referred to in this report.

PRESENT AND PROPOSED SEQUENCES OF COLLEGE PREPARATORY MATHEMATICS IN MADISON PUBLIC SCHOOL, MADISON, WISCONSIN

Tracks	7th	8th	9th	10th	11th	12th
II	Arithmetic	Arithmetic	Algebra	Geometry (Plane and Solid)	Advanced Algebra and Trigonometry	College Algebra and Analytic Geometry
Ia*	Arithmetic	Arithmetic	Algebra	Geometry (Plane and Solid)	College Algebra and Trigonometry	Calculus and Analytic Geometry
Is†	Arithmetic	Arithmetic	Algebra	Geometry (Plane and Solid)	College Algebra and Analytic Geometry (Trigonometry)	Calculus
I‡	Arithmetic (7th and 8th)	Algebra	Geometry (Plain and Solid)	Advanced Algebra and Trigonometry	College Algebra and Analytic Geometry	Calculus

* This sequence will remain in effect until the school year 1962–63.

† In this sequence an extra one semester course in trigonometry is required to transfer from the traditional sequence (track II) to the accelerated sequence (Track I).

‡ This sequence will be completely operative for grades seven through twelve during the school year 1963–64. Tracks II and Ia are being followed at the present time. When Tracks I and Is are functioning. Track Ia will be dropped and Tracks I, Is and II will remain.

BRIEF OUTLINES FOR SUGGESTED COURSE CONTENT—ELEMENTARY ALGEBRA THROUGH CALCULUS

The following outlines are not intended to be used as courses of study. They are included to give a general idea of the topics covered in each course and the sequence of the courses.

Algebra

The committee urges that all algebra teachers follow the Tentative Guide for Junior High School Mathematics prepared by the Arithmetic Committee of the Madison Public Schools, September 1958. It is essential that teachers who have accelerated or fast classes follow the suggestions of this outline very carefully.

Geometry

Prior to the school year 1958–59, plane geometry was taught as a full year course and solid geometry for twelve to fifteen weeks in the junior year. Geometry 10 b-a has integrated these two subjects into a year course which is taught at the tenth grade level or at the ninth grade level for the accelerated students. To accomplish this combination of plane and solid geometry, it was necessary to eliminate some of the topics covered in each of them. We eliminated much of the formal work of solid geometry and included only those topics necessary for advanced courses in mathematics. The greater part of plane geometry was retained. We did this recognizing current attitudes toward solid geometry and the need to include more advanced mathematics in the high school curriculum.

Topics to be covered in the geometry course should include the following:

I. Fundamental assumptions
II. Concept of formal proof
III. Congruence of triangles
IV. Parallel and perpendicular lines
V. Basic constructions
VI. Polygons
VII. Areas
VIII. Pythagorean theorem
IX. Circles
X. Locus
XI. Ratio and proportion
XII. Similarity
XIII. Points, lines and planes in space
XIV. Three dimensional solids—areas and volumes

Advanced Algebra and Trigonometry

Mathematics 11b-a

TRACKS I AND II

This course will be taken by non-accelerated eleventh grade students and in two years by accelerated tenth grade students. The algebra content is designed to review and extend the important fundamentals of elementary algebra. This course should be organized around the following topics:

I. Systems of real numbers
II. Functions
III. Complex numbers
IV. Solution of equations and inequalities
  A. Linear equations in one, two and three unknowns
  B. Quadratics and quadratic systems
V. Exponents
VI. Logarithms
VII. Trigonometric functions
VIII. Solution of right triangles
IX. Analytic trigonometry
  A. Identities
  B. Graphing
  C. Complex numbers
  D. Inverse functions
  E. Equations
X. Solution of oblique triangles

College Algebra and Trigonometry

Mathematics 11b-a

Track 1a

This is the interim accelerated course which has been taught foı the past year in the eleventh grade and will be taught in its present form for the next two years. It was developed to provide an opportunity for the accelerated students to skip one semester of algebra and to take a college level course in calculus and analytic geometry during their senior year.

The text for this course is *Integrated Algebra and Trigonometry* by Fisher and Ziebur published by Prentice Hall in 1958. It is used by the University of Wisconsin for a course in Introductory Mathematical Analysis. This particular text lends itself well to acceleration and requires a minimum supplementation to account for the ommission of one semester of algebra.

The book is organized about the concept of function and includes the following topics:

I. System of real numbers
II. Functions
  A. Algebraic
  B. Exponential and logarithmic
  C. Trigonometric
  D. Inverse
III. Complex numbers
IV. Permutations, combinations and probability
V. Theory of equations
VI. Systems of equations
VII. Sequences

The teachers who taught this course felt that it was successful, but a better evaluation will depend upon the degree of success these particular students have in the twelfth grade calculus and analytic geometry course to be offered during the coming year.

College Algebra and Analytic Geometry

Mathematics 12b-a

Tracks I, Is and II

This is a senior course for the student who wants four years of mathematics but has not qualified for the accelerated sequence. In 1962–63, this course will also serve as the accelerated eleventh grade course.

The integration of plane and solid geometry in the tenth grade

allows a more extensive treatment of analytic geometry in this course. It is felt that a student completing this course will be better prepared than previously because of this change.

The suggested algebraic content of this course is as follows:

I. Series and progressions
II. Determinants
III. Mathematical induction
IV. Binomial theorem
V. Theory of equations
VI. Permutations, combinations and probability

The suggested analytic geometry content of this course is as follows:

I. Fundamental definitions and concepts
II. The straight line
III. Conic sections
IV. Polar coordinates
V. Transformation of coordinates
VI. Higher algebraic curves
VII. Transcendental curves
VIII. Parametric expressions

Calculus and Analytic Geometry

Mathematics 12b-a

Track 1a

This course, offered for the first time in the school year 1959–60 with possible college credit, is for accelerated seniors only through the school year 1962–63. The text, *Calculus with Analytic Geometry* by Johnson and Kiokemeister, published in 1957 by Allyn and Bacon will be used. This text is being used at the present time by the University of Wisconsin for the College of Letters and Science Calculus and analytic geometry course.

During the school year 1963–64 this course will become a full year of calculus and will be taken by all accelerated students.

Suggested topics from calculus and analytic geometry to be covered are as follows:

I. Introduction to analytic geometry
  A. Fundamental definitions and theorems
  B. The straight line
  C. Analytic methods in geometry
II. Functions
III. Introduction to limits
IV. Continuity

V. Introduction to derivatives
VI. Differentiation of algebraic functions
VII. Implicit differentiation
VIII. Higher derivatives
IX. Applications of the derivatives
X. Antiderivatives
XI. Analysis of conic sections and other algebraic curves
XII. The definite integral
XIII. The fundamental theorem of calculus
XIV. Integration formulas
XV. Application of the definite integral
XVI. The definite integral as a limit of a sum
XVII. Approximations of the integral
XVIII. The indefinite integral
XIX. Trigonometric limits
XX. Differentiation of trigonometric functions

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"TWINKLING" OF RADIO "STARS" STUDIED FOR SPACE COMMUNICATIONS

How and when the radio signals sent out by heavenly objects called radio "stars" change, or "twinkle," is giving information that may aid in solving problems of communications between the earth and space vehicles.

The scintillation effects of the earth's atmosphere on radio waves from the source known as Cygnus A at a wavelength of about 13 inches has been measured. The changes in radio signals result from moving irregularities in the ionosphere, hundreds of miles above the earth's surface.

Cygnus A, a very strong radio wave source, actually consists of two galaxies, each containing billions of stars, colliding at a distance of 200,000,000 light years. A light year is the distance light, traveling at 186,000 miles a second, covers in one year.

It was found that the scintillation effects previously observed at longer wavelengths were also present at the 13-inch wavelength. The "twinkling" was usually most pronounced when the source was rising or setting. However, during auroral disturbances, strong scintillation effects were also noted when the star was high in the sky.

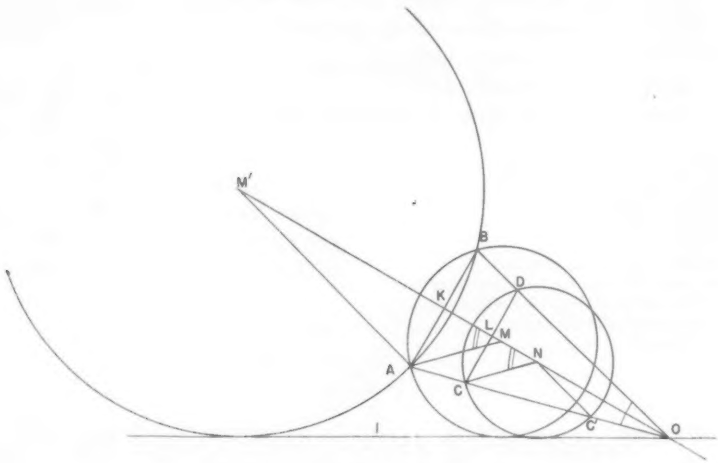
Statistical studies of the scintillation showed a variety of seasonal effects and, at certain times, a close relation to disturbances in the earth's magnetic field.

The observations were made with the 40-foot steerable dish-shaped radio telescope in a Research Foundation project conducted for the U. S. Air Force Cambridge Research Center.

Circle Tangent to a Given Line and Passing Through Two Given Points

D. Mazkewitsch
University of Cincinnati, Cincinnati, Ohio

Solutions to this problem are known.[1] One solution requires the construction of the geometric mean of two segments. The other requires much construction work and elaborate proof. Here is a simple construction.



Suppose the problem solved. Center M of the required circle lies on the perpendicular bisector KM of the given segment AB intersecting the given line l at O. With any point N on KM as center draw a circle tangent to 1. Draw OA and OB interesecting the auxiliary circle at C and D respectively. CD is $\perp$ to KM.

For: $\angle COK = \angle KOB$. From C let fall a perpendicular to KM intersecting OB at D'. Then $NC = ND' = R =$ radius of the auxiliary circle. But $ND = R$, hence D and D' must coincide, and $CD \perp KM$ and $\| AB$. Now

$$AM:CN = MB:ND$$

[1] See Nathan Altshiller-Court, *College Geometry*, 2-d ed., 1952, p. 222; Jacques Hadamard, Leçons de géométrie élémentaire, 1920, p. 154.

hence

$$\triangle ABM \sim \triangle CDN.$$

$$\therefore\ AM \| CN.$$

Hence the construction:

Draw the perpendicular bisector KM of the given segment AB obtaining O on the given line l. Around any point N of KM draw a circle tangent to l. Connect O with A intersecting the circle at C and C'. Draw NC and NC'. Through A draw parallels to NC and NC' obtaining the required centers M and M'.

The problem has two solutions. It has one solution if $AB \| 1$. It has no solution if 1 lies between A and B.

"ELECTROCUTED" COTTON FOUND MORE ABSORBENT, STRONGER

Electricity is being used in the laboratory to make cotton seed and fiber more water absorbent and cotton yarn stronger.

Exactly how the weak electric current acts on plant material has not yet been determined, U. S. Department of Agriculture scientists report, but experiments are underway to compare the strength of irradiated yarn with that of commercial chemically treated for this purpose.

Seed and fiber are placed in a large glass tube in which there is a partial vacuum and a current of between ten and 50 milliamperes passed through the tube. As the current flows through the tube, the gases in the tube glow and act on the seed and fiber.

Examination of treated cotton fiber shows its normal wax coating has been pieced in many places; fiber surface is also roughened. This roughened surface influences the yarn's breaking strength, USDA scientists pointed out. There was more than a 20% improvement in strength over untreated yarn.

The increased absorption of water by the electricity-treated cotton seed may have some relation to seed germination, survival, growth and yield of cotton. A three-year test is now in progress in three states to evaluate the electrical treatment.

RADIOISOTOPE USED IN DIAGNOSING BONE DISEASES

Diseases of the bone may be diagnosed through a new procedure which features the use of strontium-85, a safe relative of hazardous strontium-90, the fallout product.

The technique, known as an osteogram, employs tiny tracer amounts of strontium-85, which is rapidly absorbed by bone when it is injected into the body.

By placing special radioactivity detecting scintillation counters over the bone area to be studied, the rate of absorption or deposition of the strontium can be measured.

In preliminary studies of patients with various bone diseases it has been demonstrated that the rates of absorption differ in diseased bone areas from those of normal bone.

Furthermore, there seem to be differences in these rates in various types of bone diseases. Thus the osteogram patterns might be useful in determining that bone disease was present and in telling what the nature of the disease is.

Departmental Guidance for Science Majors*

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In the program to be described in this paper the school system requires one year of a biological science and one year of a physical science for graduation. The science curriculum is, therefore, divided into two tracks: one which includes a general physical science along with biology and another which includes biology and chemistry or biology and physics or both.

The lower level students are enrolled in ninth grade general physical science and follow this with biology in the tenth grade. Most of these students are non-academic and thereby get an introduction to both the physical and biological sciences. Provision is made for the late developers to follow the general physical science with chemistry and/or physics after having biology. A small per cent of the upper level students are permitted to enroll in biology in the ninth grade, but all are encouraged to defer science until the tenth grade when they take biology. During the second semester, the biology classes are segregated on the basis of previous grades and interest in science. All upper level students then take chemistry and/or physics. For all sciences a third semester is offered when students request it.

One of the primary objectives of the department is general education, therefore, students are not permitted to take advanced work in any one branch of the department without also taking introductory courses in the others. Science majors are encouraged to take four years of English and at least four years of mathematics.

The school guidance department consists of a guidance director, a junior-senior high school counsellor, a junior-senior counsellor and the home room teacher. The science department has felt the need of further guidance for all science students and especially for the prospective science majors. One phase of the program is to follow the findings of a standing committee for the academically talented student. Their program is briefly as follows:

A standing committee is in general charge of a program for the purpose of: (1) identifying the gifted; (2) encouraging maximum achievement of the individual pupil; (3) encouraging departments to provide for enrichment of curriculum; (4) improving articulation with college work.

Freshman Year

1. The first list is prepared on the basis of I.Q. All students scoring 120 and

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over on the Otis Gamms test are to be placed on the list. If others in the 115 to 119 range have high ACE scores, they are included.

2. The committee interviews such students during the second semester. Retesting should be arranged for (1) those whose high score seems invalid and (2) those not on the list whose ability, class teachers feel, is high.
3. When evidence of interest in a major area is shown through the interview, names of pupils are sent to department heads.
4. Segregation may be used as the department recommends.

Sophomore Year

1. The committee continues identification procedures with new pupils and continues retesting where necessary.
2. The committee records and summaries of interviews are turned over to the advisor in intended major department. The English department will receive the names of those whose chief vocational interest is in an English field, those whose interest may be in a general field, such as teaching and those whose interest may not be clear.
3. Department heads assign teacher advisors for students who have expressed interest in a major field.
4. Departments may have special sections if department recommends.

Junior Year

1. Department advisors council with pupils as to competition awards; vocation of choice; university or college choice; and job possibilities.
2. The committee checks with the department head or advisor on progress of pupil.
3. Departments may have special sections or begin advanced classes if department recommends.

Senior Year

1. Advanced classes are offered as department recommends.
2. Advisor and class teacher should take responsibility in the following activities: Encouraging college articulation; investigation of job possibilities; introducing men in the interest field to the student; undertaking projects when possible.
3. The committee, together with the department head or advisor, makes the final evaluation of the student's progress.

In 1955, the science teachers instituted the following plan for identification and guidance of potential science majors. During the first semester of biology, the teachers made observations of students regarding ability and interest in science. These names were submitted to the department head and were added to the names submitted by the academically talented committee. At the beginning of the second semester these names were sorted and given to those biology teachers who now had the students in class. They talked with these students as opportunity presented itself in an attempt to guide them into chemistry and physics.

The department has also developed the following outline to guide science teachers in their work with students in their classes:

I. Identification
   A. I.Q.
   B. Expressed interest in Science when interviewed by the gifted child committee.

C. Interest shown in Biology which is the first Science course.
D. Grades made in Biology.
E. Recommendation of the Biology teachers.

II. Segregation
- A. Separate class section in Biology the second semester. Students chosen on the basis of ability and interest.
- B. A Physical Science is offered for those non-major students who wish an introduction to the subject or who want a Science minor. This enables the department to maintain a higher standard of work in the regular Physics and Chemistry courses.

III. Enrichment
- A. Special speakers, audio-visual programs, etc.
- B. Reading. Departmental libraries in the classrooms with many college texts and special subject books.
- C. Field trips. Some with large groups and others with small groups or individuals with specialized interests. Trips are made outside of school time.
- D. Acceleration.
  1. Within the regular class.
  2. Offering of high school subjects out of usual grade sequence such as Biology in the 9th grade, Chemistry in the 10th grade, and Physics in the 11th grade. This permits students to take advanced courses in the 12th grade.
- E. Project work.
- F. Advanced classes offered in Biology, Chemistry and Physics. These are college freshman courses and are designed to prepare some students for the advanced standing examinations. Others use it purely for enrichment.

IV. Teacher interest
- A. We feel this is the most important aspect of the problem.
  1. Willingness to devote time outside of class.
  2. Ability and desire to inspire pupil interest.
  3. Realization that the gifted pupil learns differently.
  4. Willingness to give individual instruction.
- B. Major advisors.
  1. After students indicate interest in Science, either to the all school committee or to science teachers, a departmental teacher with special interest or training in a related field is assigned.
  2. Check programs.
  3. Introduce them to vocational possibilities.
  4. Tell them of specific opportunities of lectures, programs, shows, etc.
  5. Urge them to enter competition programs.
  6. Take personal interest in the pupil.

As a result of this guidance by the department, the enrollments in both chemistry and physics have gone up. Chemistry enrollment has gone up 12%, based on the per cent of the junior class enrolled, and the physics as much as 12% based on the per cent of the senior class enrolled.

In addition to the increased enrollment in science classes, the department teachers feel that a better job of guidance is being done for all science students.

Fuel *vs*. Weather: A Large-Scale Heat Project

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The amount of fuel used in heating a building is of economic interest. The project which is described here began as a check on the cost of heating a house. Originally, the data on fuel consumption and outside temperature were collected to determine how the cost of heating varied with the weather. Other ideas occurred, and other data were collected. Then it became interesting to see just how much could be learned from the data.

Data

The data were collected on a frame house through several winters. The figures on fuel consumption were collected each week on Saturday. The gas meter was read and the number of cubic feet used during the preceding week calculated and recorded. When oil was used, the oil in the tank was measured each Saturday and the volume used during the week calculated and recorded.[1] All oil was used in a space heater. Gas consumption included gas used for heating, cooking, and hot water. It seems reasonable to assume that all the heat used in cooking and a large part of the heat used for heating water eventually went to warm the house.

The temperature for the week was obtained from Weather Bureau data. The daily mean temperatures (average of daily maximum and minimum) were averaged for the seven days to give a weekly temperature average. In the computation of the heat used, it was assumed that 1 cu. ft. of natural gas produced 1,000 Btu. and that 1 gal. of oil produced 125,000 Btu. Data are included only for weeks where the average temperature was 65°F. or lower.[2] The fuel consumed per week Q is shown plotted against the weekly mean temperature T in Fig. 1. From the graph of $Q=f(T)$ it appears that Q is a linear function of T.

The rate at which the building cooled was also studied. The data on cooling were collected at night when the stove was turned off. The heat was turned off about 10 P.M. and started again about 6 A.M. The inside temperature was recorded in the morning at the time the heat was turned on. If, for any reason, the time of cooling was significantly more or less than 8 hr., the reading was discarded. The outside temperature for the night was calculated by taking the mean of

[1] Incidentally, marking a stick that will accurately measure the volume of fuel in a horizontal cylindrical tank was an interesting mathematical project in itself.

[2] It was found that the average fuel consumption in the summer was 5.5×10^6 Btu. per week. This is the amount of heat predicted from the regression equation (see Fig. 1) when the outside temperature is 65°F. Since fuel consumption would be constant above 65°F., these values have been excluded.

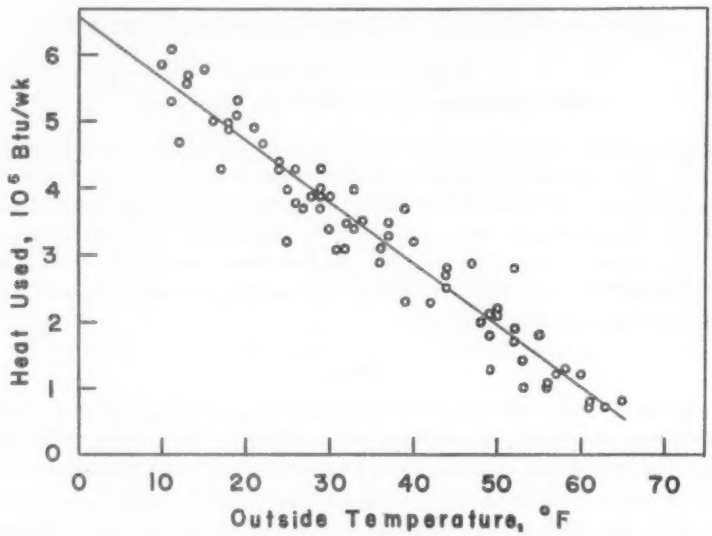

FIG. 1. Heat used to heat a house *vs.* outside temperature. If Q is the heat in millions of Btu. per week and T the outside temperature in degrees Fahrenheit, the regression equation determined by the method of least squares is $Q=6.55-0.0924\,T$.

the 10 P.M. and the 6 A.M. temperatures from the Weather Bureau reports. The inside temperature t after 8 hr. of cooling is plotted against the mean outside temperature T in Fig. 2. From the graph of $t=f(T)$ it appears that this also is a linear relation.

STATISTICAL COMPUTATIONS

If Q is the heat supplied in millions of Btu. per week, T the outside temperature in degrees Fahrenheit, and N the number of cases recorded, the sums required for computation are as follows:

$$\sum T = 2{,}515$$
$$\sum Q = 226.3$$
$$\sum T^2 = 106{,}411$$
$$\sum Q^2 = 879.11$$
$$\sum TQ = 6{,}646.9$$
$$N = 70.$$

When these values are substituted in the usual formula for the correlation coefficient,[3] we obtain

[3] Allen L. Edwards, *Statistical Methods for the Behavioral Sciences* (New York: Rinehart & Company, Inc., 1954), p. 147.

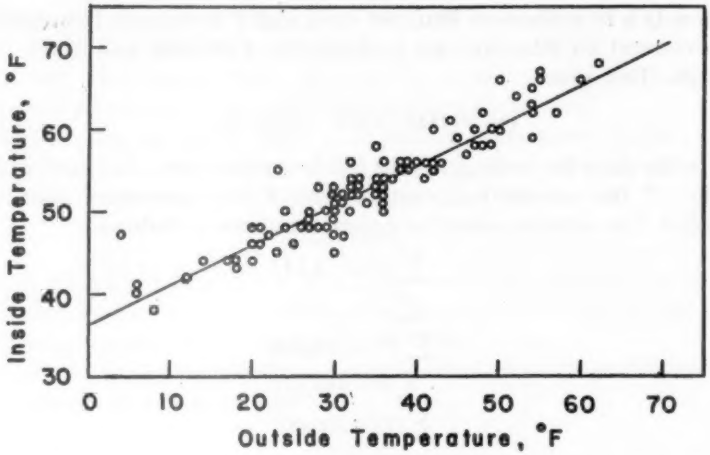

FIG. 2. Temperature of a house after cooling eight hours *vs* outside temperature. If t is the inside temperature and T the outside temperature in degrees Fahrenheit, the regression equation determined by the method of least squares is $t=36.2+0.488\,T$.

$$r=\frac{6,646.9-\dfrac{(2,515)(226.3)}{70}}{\sqrt{\left(106,411-\dfrac{(2,515)^2}{70}\right)\left(879.11-\dfrac{(226.3)^2}{70}\right)}}$$

$$=\frac{-1,483.7}{\sqrt{(16,051)(147.51)}}=-.9642.$$

Thus, the correlation coefficient between the amount of fuel consumed and the outside temperature is $-.96$.

If we assume Q and T are related linearly, we can let $Q=a+bT$. The use of the formulas for least-square coefficients[4] gives

$$b=\frac{-1,483.7}{16,051}=-0.09244$$

and

$$a=\frac{226.3}{70}+0.09244\times\frac{2,515}{70}=3.233+3.321=6.554.$$

The regression equation is

$$Q=6.55-0.0924T,$$

[4] *Ibid.*, p. 123.

where Q is in millions of Btu. per week and T in degrees Fahrenheit. To convert to Btu./hr., we multiply by 1,000,000 and divide by 7×24. This gives

$$Q=39{,}000-550T \quad \text{(Btu./hr.).} \tag{1}$$

In the data for cooling, t is the inside temperature after cooling for 8 hr., T the outside temperature, and N the number of cases recorded. The sums required for computation are as follows:

$$\begin{aligned} \sum T &= 3{,}742 \\ \sum t &= 5{,}775 \\ \sum T^2 &= 144{,}350 \\ \sum t^2 &= 310{,}277 \\ \sum Tt &= 206{,}007 \\ N &= 109. \end{aligned}$$

From these values, the correlation coefficient is found to be

$$r=\frac{206{,}007-\dfrac{(3{,}742)(5{,}775)}{109}}{\sqrt{\left(144{,}350-\dfrac{(3{,}742)^2}{109}\right)\left(310{,}277-\dfrac{(5{,}775)^2}{109}\right)}}$$

$$=\frac{7{,}750}{\sqrt{(15{,}886)(4{,}308)}}=.9368.$$

Thus, the correlation coefficient between the inside temperature after 8 hr. of cooling and the outside temperature is .94.

If we let $t=a+bT$, the regression coefficients are

$$b=\frac{7{,}750}{15{,}886}=0.4879$$

and

$$a=\frac{5{,}775}{109}-0.4879\times\frac{3{,}742}{109}=52.98-16.75=36.23.$$

The regression equation is

$$t=36.2+0.488T, \tag{2}$$

where both t and T are in degrees Fahrenheit.

It will be noticed that at no place has the inside temperature of the building been recorded under normal conditions. It can, however, be calculated in two ways.

First, Eq. (1) will be used. If we set $Q=0$ and solve for T, we obtain $T=70.9$. Thus, if the outside temperature is 70.9°F., no fuel is required. This means, then, that 70.9°F. is the normal inside temperature which is maintained during the heating season.

Second, Eq. (2) will be used. If no cooling takes place, we may assume that it is because the outside temperature T was the same as the initial inside temperature. If we set $t=T$, we have

$$0.512T=36.2,$$

which gives a solution of $T=70.7$. If no cooling occurs when the outside temperature is 70.7°F., we assume this represents the normal inside temperature during the heating season.

The two values obtained by using different methods and different data are in quite good agreement.

Theory

It is assumed that heat lost from the building is proportional to the difference between the temperature inside and the temperature outside. The amount of heat lost is then $K(t-T)$. Since this heat is supplied by the heating equipment, we have

$$Q=K(t-T). \tag{3}$$

If the inside temperature t is assumed to be constant ($t=t_0$), we can write

$$Q=Kt_0-KT. \tag{4}$$

Thus, Q is seen to be a linear function of T as was suggested from the graph in Fig. 1.

By equating coefficients in Eqs. (1) and (4), we find that $K=550$ Btu./hr. °F. and that $Kt_0=39{,}000$ Btu./hr.

If the heat is turned off in the building, it will cool, it is assumed, at a rate proportional to the difference in temperatures inside and outside. Let T be the outside temperature, t the inside temperature, and τ the time. Then

$$dt/d\tau=-p(t-T), \tag{5}$$

where p is a constant. Separating the variables, we have

$$dt/(t-T)=-p\,d\tau.$$

Upon integrating both sides, evaluating the integration constant by substituting initial conditions of $t=t_0$ when $\tau=0$, and substituting the value of the integration constant back in the equation, we have

$$\ln(t-T)=-p\tau+\ln(t_0-T). \tag{6}$$

If ln (t_0-T) is transposed to the left and the antilogarithm taken on both sides, we have

$$\frac{t-T}{t_0-T}=e^{-p\tau}.$$

Multiplying through by t_0-T and transposing T to the right, we obtain

$$t=T+(t_0-T)e^{-p\tau}. \qquad (7)$$

Thus, if t_0 and T are both constant, the inside temperature during cooling is an exponential function of the time τ.

Equation (7) can be rearranged to give

$$t=t_0e^{-p\tau}+(1-e^{-p\tau})T. \qquad (8)$$

If the cooling occurs for a fixed length of time (τ=constant), then the inside temperature t is a linear function of the outside temperature T. This was suspected from examination of Fig. 2.

If the coefficients in Eqs. (2) and (8) are equated,

$$1-e^{-p\tau}=0.488$$

is obtained. After substituting the value $\tau=8$ hr. and solving for p, we find $p=-\frac{1}{8}\ln 0.512=0.0837$ hr.$^{-1}$. Units for p are reciprocal hours (written hr.$^{-1}$ or /hr.).

By starting with a more general equation, we can derive both Eqs. (3) and (5) as special cases. In addition, the total heat capacity C of the building can be determined from empirical values of K and p. From the first law of thermodynamics, we can write

$$Q=\int K(t-T)d\tau+\int C\frac{dt}{d\tau}\,d\tau, \qquad (9)$$

where Q is the heat supplied, K is the *total thermal conductivity* in in Btu./hr. °F., t is the internal temperature and may vary with time, T is the outside temperature and is assumed constant, τ is time, and C is the *total heat capacity* of the building in Btu./°F.

If t is held constant, the second integral vanishes because $dt/d\tau=0$, and the first integral becomes $K(t-T)\tau$. If $\tau=1$ hr., Eq. (9) then reduces to Eq. (3).

If no heat is supplied ($Q=0$) and the building is allowed to cool, Eq. (9) becomes

$$\int C\frac{dt}{d\tau}d\tau=-\int K(t-T)d\tau. \qquad (10)$$

Equating the integrands and dividing through by C, we find

$$\frac{dt}{d\tau} = -\frac{K}{C}(t-T), \tag{11}$$

which is the same form as Eq. (5). If the coefficients in Eqs. (5) and (11) are equated, we have $p = K/C$ or

$$C = K/p. \tag{12}$$

Substituting values of $K = 550$ Btu./hr. °F. and $p = 0.0837$ /hr., we have

$$C = \frac{550 \text{ Btu./hr. °F.}}{0.0837 \text{ /hr.}} = 6{,}570 \text{ Btu./°F.},$$

which is the total heat capacity of the building.

Conclusion

By the time the project was finished—if such a project is ever finished—it had involved much more than comparison of fuel consumption with the weather. Something similar might be useful as a class project: the data are easily obtained and the variety of activities—collection of data, plotting data, statistical computations, and theoretical development—should provide a job suitable to the ability of any student. Many variations are possible. There is an abundance of projects to plan, problems to solve, and questions to discuss. The following are examples:

1. The total thermal conductivity K of the building is in Btu./hr. °F. The coefficient of thermal conductivity k of building materials is expressed in Btu. in./ft.^{2} hr. °F. Therefore $k = Kd/A$, where d is the thickness of the wall in inches and A is the area of the surface in square feet. The value of k is a characteristic of the building materials while K depends on the nature of the materials and on the dimensions of the building. After determining K for the building and measuring A and d, determine k, which will be an average value for the materials in the building. How does the value of k for common building materials compare with the value determined for the building?

2. Measure the volume of the building and compute the total heat capacity of the air in the building using values of density and specific heat from reference books. Should specific heat at constant pressure or constant temperature be used? How does the heat capacity of the air compare with the total heat capacity of the building? When a building is warmed up, what fraction of the heat goes to warm the air?

3. The total heat capacity C of the building is in Btu./°F. The

specific heat c is a characteristic of the material and is expressed in Btu./lb. °F. If m is the mass of the building, we have $C=cm$. Make an assumption as to the average heat capacity of the building (e.g., $c=0.2$ Btu./lb. °F.) and determine the mass of the building using $m=C/c$. How does this compare with an estimate made by a contractor or a house mover as to the "weight" of the building?

4. The mass determined above will include the mass of the air in the building. Compute the mass of the air fiom the volume and density. Is this a significant portion of the total mass of the building?

5. Is specific heat expressed in Btu./lb. °F. the same as when expressed in cal./g. °C.? If it is the same, why? If it is not the same, what is the conversion factor?

6. Equation (1) is the regression equation used to predict Q from T. Calculate the regression equation by the method of least squares to predict T from Q. How does this equation compare with the one obtained by solving Eq. (1) for T?

7. There are many questions that could be discussed: What is a degree day? Is there a better method of determining the outside temperature than the one used here? The Weather Bureau temperature was measured at a point about 5 mi. from the house. Should this have been considered? There are several points on the graph that appear about 10° too high. Should one consider them errors in reading the thermometer and discard them? How many significant figures are there in the number 39,000 in Eq. (1)? How about the value of $C=6,570$ Btu./°F.? Is there a better way to write these numbers? How could an experiment be planned to study the effect of wind on the heat loss of a building? How would one study the saving of fuel due to insulation? Is it possible from the data given here, to estimate the amount of fuel saved by leaving the heat off for 8 hr. each day?

ALUMINUM AND THORIUM BONDED BY NEW METHOD

A method of forming a strong metallurgical bond between aluminum and radioactive thorium has been patented. It has application in the nuclear energy field where thorium fuel elements are coated with aluminum to facilitate heat transfer and prevent corrosion.

Bonding the two metals is difficult because of their dissimilar nature. Earlier aluminum-thorium bonds have been produced, but they have lacked the necessary thermal stability for service at high temperatures. Trouble was experienced in the form of warpage, weld breakage and separation of the bond.

The new method comprises placing clean surfaces of thorium and aluminum in contact with each other and hot-pressing the metals together in an inert atmosphere or under a vacuum. By hot-pressing at a temperature range of about 700 degrees to 1,000 degrees Fahrenheit, a strong, adherent bond is obtained.

Old Concepts with New Ideas*

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Concepts, even in such an active science as biology, are not necessarily obsolete because they are old. But discoveries are always being made, data rearranged, and new conclusions drawn. The familiar word or phrase assumes a new richness of meaning, a deeper and more fruitful connotation. Because of this continual flowering of knowledge, a flowering today perhaps more brilliant in biology than in any other field of science, the perennially useful ideas must often be reexamined, so that we do not pass by the subtle changes in meaning that have taken place.

One such concept is that of biology. It is always useful to define biology, and the words of the definition do not change too much with the years. Biology is defined as the science of life, or as the scientific study of living things. The critical terms are *science* and *life*. What is science? The word is personified, almost deified, so that "science says" has become almost as final as "the church says." Now science is not a person. It is a language, a method, a body of knowledge. Considered as a language, it is distinguished by precision. It need not be technical. Adenosine triphosphate, lectotype and adrenocorticotropic hormone sound very fine. However, they are not of the essence of scientific language, although precision is. Unfortunately, many of the words commonly employed in a language are imprecise in meaning, being used to denote two or even more different ideas. One who wishes to be exact is driven to invent a technical vocabulary, defining each word carefully, so that it means no more and no less than he wishes it to mean. Such a vocabulary is semantically correct, and is scientific.

Scientific method is any method which allows another to verify the results. Neither the experimental method, which is the method most frequently called *the* scientific method, nor any other method used by scientists is universally applicable. Sometimes scientific method is mathematical or statistical. Sometimes a problem is pursued through two or more different systems, beginning with different sets of axioms. If the same answer is obtained in each case, the solution has been demonstrated scientifically. In some cases, reliance is placed upon a trained judgment; the results are not verifiable by another, and an art is practiced under the name of science. One should be prepared to point out that there are diverse methods of arriving at scientific knowledge, and that no one of these methods can be used exclusively. In most cases, the methods permit verification, but not always.

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Science is a body of knowledge. It is not hearsay, or empirical knowledge, but knowledge arrived at by scientific method. It is related to a core principle, which correlates all of its factual data. It is this relationship to a principle which defines the individual sciences, separating the biological from the physical and the social sciences. It is also knowledge of sensible matter, which makes materialism an ever-present threat to the scientist. The principle which correlates the biological sciences is that of evolution, which now promises to be the unifying principle of the whole material universe.

The second significant term with which we deal is life. This is most commonly defined in terms of the vital functions. The vital functions, however, are performed by a remarkably organized material called protoplasm, which should be included in the description. The organization begins with the bonding of carbon atom to carbon atom, and continues through complex molecules found nowhere else in nature, through nucleic acid-protein complexes, to chromosomes, to nuclei, to cells, and on to organisms. The carbon-to-carbon bond does not occur in nature except in living things: does it then define life? Are the nucleic acid-protein complexes that we call viruses alive? They use the enzymes of their hosts to perform their vital functions, but they are specific, and they duplicate themselves. Does that make them live? The new activity of the carbon atom is demonstrated only in living things, but it was the first step toward life. Subjection to natural selection may be the test for aliveness; the test may be the ability to perform all of the vital functions. No one has decided, and the division between living and non-living is not distinct. The living thing has a most intimate relationship with the environment. It is an "open system" receiving from and contributing to the media in which it is immersed, excluding entirely certain elements which surround it; holding others at a concentration above that of the substrate, while permitting yet others to pass freely in and out. This implies a boundary of unusual properties, and such a boundary is an essential part of a living thing. A living thing, then, has its beginning in the bonding of carbon to carbon, elaborates itself to the level of the complex organism, performs functions that are not basically elaborated once they are established, is intimately related to the environment, yet maintains its identity by an unusual delimiting membrane.

Biology is usually divided into various subsidiary sciences, theoretical or applied. The division is not logical, and some of the sciences are defined in terms of the body of knowledge; e.g. mycology, botany, zoology, herpetology. Others are classified in terms of functions, as physiology, and ecology. Some deal with method—classification. Botany is a science that seems to require a high degree of sophistication for its appreciation. Young students often find it dull, basically

because their teachers think that it has little to offer. There is wealth of knowledge that can be studied in the laboratory, seriously and at the level of original contributions, in the field of botany. The importance of chlorophyll cannot be overestimated, and photosynthesis alone makes the study of plants essential. The fixation of carbon dioxide by plants has been studied from before the French Revolution until the present day, and it is not yet understood. It is trite to say that the food supply of the world depends upon it, but young students do not find plants interesting. The refinements of method and of measurement that are involved in feeding radioactive carbon dioxide to *Chlorella* are instructive and beautiful, although probably not to be attempted in the classroom. Some of the neatest and most elegant of modern experimental work has been that which associated the so-called "tropisms" of plants with growth or the movement of water, and with the differential action of hormones. Children—and some textbooks—still tell us that plants "seek the light." We, I fear, do not.

The induction of flowering and the photoperiod may be studied in laboratories with little equipment, by young persons with little background or experience. Some one might even find something new. Mineral nutrition can be studied in plants, with results just as conspicuous as those detected in nutrition studies with animals. There is a great deal of literature that is not difficult, and plants are easier to house than rats. A little more attention to processes may be all that is needed to make plants almost as interesting as pets.

Most textbooks devote at least some attention to the classification of living things. There is no better way of calling attention to the great number of kinds of living things. There are perhaps a hundred thousand plants, about a hundred thousand fungi. There are over a million kinds of animals, about 80% of them insects. Why this is so makes a very interesting problem. The species is the basic taxon, and species are determined by studies of populations, although in practice all museum workers are aware that all too frequently a decision about a new species, and even a new genus, must be made upon the evidence of a single specimen, collected fifty years before in the jungles of a country now inaccessible.

Most elementary textbooks recognize ten or twelve phyla of animals, four of plants. Most do not indicate that there are about twice that number of animals, that plants belong in divisions, and that the four categories for plants are truly obsolete, not merely old concepts in need of enrichment. Modern classification recognizes every aspect of the living thing—its fossil relatives, its physiology, ecology, geography, cytology, its vegetative as well as its reproductive morphology. The possession of a basic complement of chromo-

somes is probably the *ideal* determination of a species, and multiples of that basic complement the higher taxa. For at least twenty-five years the four divisions of the plant kingdom have been superseded because of those requirements, but the knowledge has penetrated very slowly. Students might be taught to write simple keys—the first keys to a few of their classmates, then keys to orders, to families, or very small numbers of genera or species. This might lead to a wider and more desirable knowledge of living things than the memorizing of orders and of life cycles.

It may be time for us to rethink some of our knowledge of the vital processes. To do this, we must reconsider the structure of protoplasm. A colloidal solution cannot possibly perform the functions that even the simplest protoplasm performs. The known portions of the process by which energy is released from sugar involve about 25 enzymes, not to mention the transfer system for the energy produced. All of this implies a fixed relationship among the parts of protoplasm; a cellular protoplast may be a sort of super- or polymolecule.

Probably all vital processes are catalyzed reactions. This makes the number of enzymes in a single cell almost unimaginable. A study of digestion, in the animal, is a process occuring entirely outside the body. It does not give a picture of the enzymes in muscle, at nerve endings, in storage tissue, in or near actively transporting membranes, or respiring and synthesizing within the cell. The cell scintillates with activity, carried on at a speed and at a temperature possible only with catalysis.

A little care might be given to the concept of energy. In all living things, and in all heating by fuel, energy comes from the opening of the carbon bond, and the eventual transformation of the carbohydrate to carbon dioxide and water. It is transferred and made available in the high-energy phosphate bond, not found in inorganic compounds, and is manifested most conspicuously in the shortening of muscle and in the production of light, of electricity, and of heat. To be alive means constantly to be transforming energy within every cell, releasing it so smoothly that there is never a pause in the process.

Little attention is paid to growth in elementary classes. Young people are aware of their changes in height and weight. The study of growth affords another process that may be followed with simple instruments which give accurate results. Beautiful curves can be plotted. Students count yeast cells with a counting chamber, record increments of mass in baby mice, increments in height in plants. Differential curves may be obtained by comparing total increases in the length of young mice with the growth of the tail.

It is possible to be a little more precise in describing the functions of vitamins, and of hormones. Those vitamins whose function is

known are associated with enzymes, usually as the coenzyme. The role of the B-complex is fairly well established. Students should not say that we do not know how vitamins act, nor give external symptoms as the action of vitamins.

Hormones, like vitamins and enzymes, are present in minute quantities. While their action is less well known than that of vitamins, they are associated with the action of enzymes, a few with specific enzymes. They seem to activate enzymes, as hydrogen ions activate pepsinogen.

Finally, we might mention genetics and evolution. We know the gene much less well than we formerly did. "A gene is the smallest portion of a chromosome that will not undergo crossing over." The Abbot Mendel is an outstanding example of a man who asked of nature the questions she was able to answer. That is excellent, if one keeps well in mind that he does not have the whole answer. So frequently post-Mendelian genetics is neglected. The neat, single-gene characters located on separate chromosomes, the mono- and dihybrid crosses and some too-much simplified information on the color of the eyes and of the hair of humans, and we have taught genetics. It is hard to omit the low I.Q. and the horrible example of Martin Kallikak the noble example of Jonathan Edwards, so they are included.

It is extremely hard to teach the adolescent or the young adult that much of our knowledge is not absolute, and that the courage to go on toward goals of rectitude ane virtue in the face of real uncertainty is a mark of maturity. This is one of the places in which he is not secure. Mutations must be faced—the presumed chemical changes that are genetic mutations, the larger, often more conspicuous changes that result from reversals, inversions, crossing-over and altered linkages. The student must project his knowledge of the dynamic system into his study of the nucleus, realize the impact of gene upon gene, and of environment upon all. The study of the environment should be not merely a study of radioactivity, but of the workaday environment, so little studied or understood. The isolation of a pool of genes in a population, the importance of sexual reproduction and of natural selection need attention, rather than the Jukes.

We are faced with all sorts of students: fundamentalist, liberal, free-thinking. Some are waiting for an opportunity to throw off restraint. All must be encouraged to be honorable. They must face the great mass of factual data, not denying it, or its implications. To do otherwise is to be dishonest. On the other hand, they must realize that the data are not complete, and that from them can be derived no principles that explain such phenomena as those of consciousness, or of the consequences of consciousness. Modern evolution is not organic evolution, it is cosmic evolution. It is the creation of the uni-

verse. Its origin and its future are as mysterious to us as they were to primitive man. But any admission of inability to find out will stifle learning. The next telescope may furnish us with the information we need to devise a new theory for the origin of the universe, a more adequate one than we have ever before had; the next city uncovered, the next skeleton removed from its grave may fill a particularly annoying gap, and make our history of this planet more nearly complete. If the study of life science widens the student's appreciation of time and of space, if it makes him less unwilling to live with uncertainty, more able to reserve his judgments, and deepens his appreciation of the precious gift of life it will indeed have been successful.

TWO LOW-MELTING ELEMENTS MAKE HIGH HEAT MATERIAL

Two chemical elements, both of which will melt in the sun on a hot day, have been combined to produce a material capable of withstanding temperatures up to 1,500 degrees Fahrenheit.

Gallium phosphide, a yellow compound resembling ground glass, has been prepared from gallium, a rare silvery metal, costing about $1,500 a pound, and phosphorus, used in matches, by the U. S. Army Signal Corps Research and Development Division, Fort Monmouth, N. J.

The material may be used in building solar-cell power plants for space stations, and tiny rugged electronic parts for missiles, satellites and space probes of the future. So far the Army Signal Corps has built an electronic diode of gallium phosphide which has withstood temperatures seven times higher than those withstood by the now-used silicon and germanium.

Further research will be done to determine the properties of the material before it is passed on to the Army Signal Corps equipment development engineers.

Central Association of Science and Mathematics Teachers

REPORT OF THE FIFTY-NINTH CONVENTION

November 26–28, 1959, Congress Hotel, Chicago, Illinois

I. BOARD OF DIRECTORS MEETING

Thursday, November 26, 1959, 4:00 p.m. (CST), Buckingham Room

Roll Call

Officers: McCormick, Soliday, Kennedy
Directors: Bullington, Gourley, Grubbs, Hach, Hardy, Hauswald, Shetler, Sistler, Woline
Journal Officers: Mr. and Mrs. Mallinson

Minutes of 1959 Spring Board Meeting: The sentence, "He also said that it has been the policy of the Editor to include advertisements in the *Journal* without thorough investigation." was deleted from the comments on Mallinson's *Journal Report.* With this correction the minutes were approved.

Report of Nominating Committee: The successful candidates in the recent election are:

President: James H. Otto
V. Pres.: Lawrence A. Conrey

Directors: William A. Hill
Donovan Johnson
Sister Mary Ambrosia
Glenn David Vannatta

The Nominating Committee proposed that the Board elect one of the four nominees for Director who were not elected in the fall election to fill the vacancy created by Beckett's resignation.

Hach moved, Hardy seconded that the nominee receiving the fifth highest number of votes in the fall election be chosen to fill the vacancy created by the resignation of Beckett. Motion carried. Mr. Aubrey Wood received the fifth highest number of votes.

Election of Representative to AAAS: The Executive Committee had been asked to make a recommendation for this position before the fall meeting. They presented a slate of four qualified individuals at the meeting. After discussion of the advantages of belonging to AAAS and the problems of having continuity of representation Mallinson suggested that $200–300 should be made available for expenses for the representative. Shetler moved, Gourley seconded that expenses up to $250 per year be allowed the representative. Motion carried. A paper ballot was taken to choose the representative. The results showed that Mallinson was favored by a majority of the Directors. Hach moved and Bullington seconded that we elect Mallinson by a unanimous vote. Motion carried. Mallinson accepted saying that he would not request expenses and that an understudy should be chosen soon.

Grubbs moved, Hauswald seconded that the Executive Committee should make a recommendation at the Spring Board Meeting with regard to the AAAS representative understudy. Motion carried

Mr. McCormick said that he was asked by Mr. Daniel W. Snader of the U. S. Office of Education to appoint Glenn Ayre to an advisory committee. Mr. Ayre's expenses as a representative of CASMT were to be paid by Mr. Snader's organization. Mr. McCormick did appoint Mr. Ayre after receiving advice from other Officers.

Report of Place of Meeting Committee: Mr. Sistler reported that his committee had chosen Detroit for the 1960 meeting and Chicago (or the Chicago area) for the 1961 meeting. He moved, Hardy seconded that we meet in these places at these times. Carried.

Treasurer and Business Manager's Report: Mr. Soliday presented a profit and loss statement which showed that the fiscal year ending June 30, 1959 had been profitable. The net profit $3,151.51 is the largest on record. Our membership is at a new high of 1,439 and 5,500 copies of the *Journal* are being printed. Gourley moved, Sistler seconded that we accept Mr. Soliday's report. Motion carried.

Report of Salary Committee: Mr. Grubbs reported that his committee favored an increase of $600 per year in the salary of the Treasurer and Business Manager and an increase of $300 per year in the salary of the Editor of the *Journal*, both increases retroactive to July 1, 1959. The third paragraph of this report concerned a possible future increase in the Editor's salary. Grubbs moved, Hach seconded that we approve this report. Grubbs amended the motion to strike out the third paragraph of the report. Gourley seconded and the amendment carried. Main motion carried.

The meeting adjourned for dinner and the evening program, then reconvened at 9:30 P.M.

Report of Journal Editor: Mr. Mallinson's report showed that sufficient materials (not including convention papers) are on hand to fill the *Journal* through February, 1960. He pointed out that CASMT members and subscribers do not provide enough high-quality material to fill the issues.

Mallinson showed Volumes II and IV of the *Journal*. These volumes, which had been reproduced by University Microfilms, Inc., completes the Editor's archives. He also expressed approval of our relationship with Banta, the firm which publishes our *Journal*. Kennedy moved, Hardy seconded that we receive this report. Carried.

Report of the Yearbook Editor: Hardy moved, Hauswald seconded that we receive this report. Motion carried.

Reports of the Local Arrangements Committee, Membership Committee, and Publicity Committee were accepted. Committee Reports from Hospitality and Reception, Tours, Facilities and Visual Aids, Luncheon, and Statistics were received.

President McCormick expressed his appreciation for the fine, cooperative spirit over the past two years. He said that it had been a priceless experience.

The Board voted its thanks to Mr. McCormick for his excellent work.

Meeting adjourned at 10:15 P.M.

II. ANNUAL BUSINESS MEETING

FRIDAY, NOVEMBER 27, 1959, 10:00 A.M., GOLD ROOM

Mr. McCormick called the meeting to order.

Nominating Committee Report: Mr. Bos announced the new Officers and Directors as reported above. He said that 440 ballots had been sent in by members for this year's election.

Mr. McCormick acknowledged the good work of this committee.

Mr. McCormick recognized the good work of the Policy and Resolutions Committee and its chairman, Mr. Read. This committee's report presented at the Spring Board Meeting called for several By-Laws amendments. The amendments had been published (see SCHOOL SCIENCE AND MATHEMATICS, vol. 59, pp. 206, 303, 574, 670) as required and were acted upon at this meeting. Article I, Sections I, II, III, IV and Article V, Section V were amended on motions from Kennedy, seconds from Read, and voting by the members present.

The meeting was adjourned at 10:40 A.M.

III. BOARD OF DIRECTORS MEETING

SATURDAY, NOVEMBER 28, 1959, 2:00 P.M., BUCKINGHAM ROOM

Roll Call:

Officers: Otto, Soliday, Kennedy

Directors: Ambrosia, Bullington, Grubbs, Hach, Hardy, Hill, Johnson, McCormick, Sistler, Vannatta, Wood

Committee Chairman: Read

Editors: Mallinson, Shetler

Mr. Otto asked that the Board advise him of their wishes with regard to the theme of next year's convention and to the general structure of the program. It was suggested that we try to avoid conflicts with other groups by cooperating with them at convention time.

The Spring Board Meeting has not yet been scheduled, but it will be in late April or early May.

Mr. Mallinson reported that University Microfilms, Inc. were willing to pay half their usual fee of $972 to film the entire *Journal.* While our present stock of reprints would be protected, royalties on future reprints of all issues would be divided. Woline moved, Sistler seconded that we receive the report and refer it to the Policy and Resolutions Committee for a recommendation at the Spring Board Meeting. Motion carried.

Mr. Otto acknowledged the good work of the Policy and Resolutions Committee in the past year and announced that Mr. Read had been reappointed as Chairman. Mr. Read then reported that his committee had met at the convention, but was unable to consider several major items in a short session. It was pointed out that anyone could refer a problem to the committee, but that resolutions should be made only to the Board.

Mr. Otto announced that Reginald Porter had been reappointed Chairman of the Membership Committee. This committee now has the additional responsibility of general Association publicity.

Mr. Kennedy reported on a communication from the Section Officers. This communication was in the form of an advisory and informed the Board that the Section Officers were in favor of moving the convention date to the latter part of August to avoid bad weather, the Thanksgiving holiday, regular school sessions, and high hotel costs. They noted that such a meeting time would permit the use of college dormitory space and would allow greater freedom in convention location. The Board discussed various means of obtaining the desires of the entire membership. Mr. Read asked for the Board's opinion on this advisory. Three directors voiced an opinion; one for, one against, and one divided. Bullington moved, Woline second that this problem be referred to the Policy and Resolution Committee.

Mr. Soliday asked Board approval of the use of the River Forest State Bank and Trust Company, River Forest, Illinois as the depository of our funds. Kennedy moved, Johnson seconded that this approval be granted. Carried.

Mr. Soliday also reported that it may be possible to obtain Social Security coverage for our employees. After some discussion Woline moved, Hach seconded that Mr. Soliday investigate this matter further and report his findings at the Spring Board Meeting. Motion carried.

The meeting was adjourned at 3:25 P.M.

Respectfully submitted,
JOSEPH KENNEDY
Secretary

PROBLEM DEPARTMENT

Conducted by Margaret F. Willerding
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note: Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2694. *Herbert R. Leifer, Pittsburgh, Pa.*

2695. *Proposed by Leo Moser, University of Alberta.*

Four brothers now living were born on 4 different years of the same decade. The four years of birth involved are all prime numbers. How old are they now?

Solution by Richard D. Stratton, Nebraska State Teachers College at Chadron

I assumed that not one of the four brothers is over 100 years old at the present time. Then I used a list of prime numbers to find four numbers (years) that are in the same decade beginning with the number (year) 1859. I found that the four numbers to be 1871, 1873, 1877, and 1879. Therefore the ages of the four brothers are 88, 86, 82, and 80 years old. (The following are the prime numbers from 1859 to 1959: 1861, 1867, 1871, 1873, 1877, 1879, 1889, 1901, 1907, 1913, 1933, 1949, and 1951.)

Solutions were also offered by Wayne Brown and James Key, Nashville, Tenn.; Margaret Joseph, Milwaukee, Wis.; Cecil B. Read, Wichita, Kans.; Walter R. Talbot, Jefferson City, Mo.; and the proposer.

2696. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kans.*

Show that

$$\frac{1}{1\cdot 2\cdot 3}+\frac{1}{3\cdot 4\cdot 5}+\frac{1}{5\cdot 6\cdot 7}+\cdots+\frac{1}{(2n-1)(2n)(2n+1)}+\cdots$$

is equal to $\ln 2-\frac{1}{2}$.

Solution by the proposer

Using the well known series for

$$\begin{aligned}
\ln(1+x)&=x-\tfrac{1}{2}x^2+\tfrac{1}{3}x^3-\tfrac{1}{4}x^4+\cdots\\
2\ln 2&=2(1-\tfrac{1}{2}+\tfrac{1}{3}-\tfrac{1}{4}+\tfrac{1}{5}-\tfrac{1}{6}+\cdots)\\
&=2-\tfrac{2}{2}+\tfrac{2}{3}-\tfrac{2}{4}+\tfrac{2}{5}-\tfrac{2}{6}+\cdots\\
&=1+1-\tfrac{1}{2}-\tfrac{1}{2}+\tfrac{1}{3}+\tfrac{1}{3}-\tfrac{1}{4}-\tfrac{1}{4}+\tfrac{1}{5}+\tfrac{1}{5}-\tfrac{1}{6}-\tfrac{1}{6}+\cdots\\
&=1+(1-\tfrac{1}{2})-(\tfrac{1}{2}-\tfrac{1}{3})+(\tfrac{1}{3}-\tfrac{1}{4})-(\tfrac{1}{4}-\tfrac{1}{5})+(\tfrac{1}{5}-\tfrac{1}{6})-\cdots\\
&=1+\left(\frac{1}{1\cdot 2}-\frac{1}{2\cdot 3}\right)+\left(\frac{1}{3\cdot 4}-\frac{1}{4\cdot 5}\right)+\left(\frac{1}{5\cdot 6}-\frac{1}{6\cdot 7}\right)+\cdots\\
&=1+\frac{2}{1\cdot 2\cdot 3}+\frac{2}{3\cdot 4\cdot 5}+\frac{2}{5\cdot 6\cdot 7}+\cdots
\end{aligned}$$

Division by 2 and transposition verifies the given formula.

Solutions were also offered by Walter R. Talbot, Jefferson City, Mo.; and L. Thomas, Nashville, Tenn.

2697. *Proposed by Bjarne Skaug, Oslo, Norway.*

Between two intersecting lines m and l is given one point P. Find an equilateral triangle having one vertex at P and one on each of the straight lines.

Solution by Walter R. Talbot, Jefferson City, Mo.

Let m and l meet in O and draw OP, on, say, the same side of O as P, take points A on l and B and C on m. On, say, the sides away from O, construct equilateral triangles on AB and AC. Let third vertices be D and E. Draw DE and let it meet OP in F.

On the side of AF away from O, construct the equilateral triangle AFG. G will lie on m by Theorem 51, page 49 of Altshiller-Court's *College Geometry* (1952): If one vertex of a variable triangle is fixed, a second vertex describes a given straight line, and the triangle remains similar to a given triangle, then the third vertex describes a straight line.

By the Theorem of Desargues we obtain the desired triangle at P by making its sides parallel to those of AFG and terminating them on m and l.

Solutions were also offered by Stanley Payne, Hastings, Neb.; and the proposer.

2698. *No solution has been offered.*

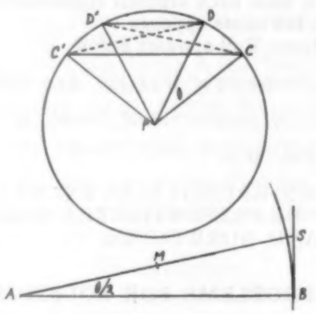
2699. *Proposed by Brother T. Brendan, St. Mary's College, Calif.*

In an article by Prof. Buck in the March, 1959, *American Mathematical Monthly*, 207, we find mention of the following problem given to eighth-graders in the national competition of 1956 in the USSR: "Through two given points on the circumference of a circle draw two parallel chords having a specified sum." Find such a construction for those cases where the given conditions permit it.

Solution by the proposer

Let the given circle be at P with C and D the given points on the circumference, making an arc CD whose central angle is θ. Let AB be the "specified sum."

Construction: Construct an angle equal to $\theta/2$ on AB at A, and construct a perpendicular at B intersecting the side AS of angle $BAS=\theta/2$ at S. Bisect AS at M. Using AM as radius, and points C and D as centers, construct arcs marking off respectively points C' and D' on the given circle—so that $CD'=AM=DC'$. Join DD' and CC'. These are the required chords.



Proof: First, it is clear that DD' is parallel to CC'. For, since $CD'=DC'$, angle CPD'=angle DPC'; when we subtract angle DPD' from each, we get angle $D'PC'=\theta$. That is, the two chords, DD' and CC', intercept equal arcs and so are parallel. Second, the chords have the specified sum, AB. For, it is clear from the size of the intercepted arcs that angles $DC'C$ and $C'DD'$ are both equal to $\theta/2$. Also it is clear that $CDD'C'$ is an isosceles trapezoid. Hence, we readily find that, since

$$AM=\tfrac{1}{2}AS,\ DD'+CC'=2(AM\cos\theta/2)=AS\cos\theta/2=AB.$$

A solution was also offered by Walter R. Talbot, Jefferson City, Mo.

2700. *Proposed by J. B. Flansburg, Houston, Texas.*

Prove that there is no n for which the value of

$$1/2+1/3+1/4+\cdots+1/n$$

is integral.

Solution by J. W. Lindsey, Amarillo, Texas

This is a harmonic series, and may be written thus:

$$1+1/2+1/3+1/4+\cdots+1/n. \tag{1}$$

It is evident that

$$1+1/2>1/2$$
$$1/3+1/4>2/4$$

$$1/5+1/6+1/7+1/8>4/8$$
$$1/9+1/10+\cdots+1/15+1/16>8/16$$

Adding for c groups, we have

$$1+1/2+1/3+1/4+\cdots+1/2^c>c/2. \qquad (2)$$

Taking the limit as c approaches infinity, it follows from (2) that (1) increases without limit. Hence the harmonic series is divergent even though its nth term approaches zero as n approaches infinity.

Solutions were also offered by G. P. Speck, Virginia, Minn.; Walter R. Talbot, Jefferson City, Mo.; and L. Thomas, Nashville, Tenn.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2695. *Lee H. Mitchell, University of Michigan, Ann Arbor, Mich.*

2695. *Gary Montgomery, St. Gregory School, Detroit, Mich.*

2697. *Lief Grundt, De Pere, Wis.*

EDITOR'S NOTE. MR. GRUNDT IS AN EXCHANGE STUDENT FROM RJUKEN, NORWAY. HE PRESENTED THE SOLUTION TO PROBLEM 2697 IN ENGLISH AND NORWEGIAN.

PROBLEMS FOR SOLUTION

2719. *Proposed by Cecil B. Read, Wichita, Kans.*

Given that a is quite small as compared to b and c. Find an approximation to the numerically smaller root of the quadratic equation

$$ax^2+bx+c=0.$$

2720. *Proposed by Walter R. Talbot, Jefferson City, Mo.*

Evaluate the real positive function:

sin arc tan sec arc csc cot arc cos csc arc cot cos arc sin tan arc sec y.

2721. *Proposed by Brother Felix John, Philadelphia, Pa.*

The sides of a right triangle are a, b, and c, and the areas of the triangle is 84 square units. The sides of a second triangle (not right) are d, e, and f, and these sides form an arithmetic progression with a common difference of 1. If d is 1 less than twice a, and e and f are each 10 less than b and c respectively, find a, b, c, d, and e.

2722. *Proposed by J. W. Lindsey, Amarillo, Texas.*

Find the equation of the circle tangent to the lines $y-3x=20$ and $x+3y=10$ and passing through the origin.

2723. *Taken from* Mathematical Pie.

Three fierce dogs, Alpha, Beta, and Gamma, stand at the vertices of a large equilateral triangle. At a given signal, Alpha chases Beta, Beta chases Gamma and Gamma chases Alpha, all with the same speed. Sketch the paths run by each of the dogs.

2724. *Proposed by Walter R. Talbot, Jefferson City, Mo.*

Clocks A and B were started at the correct time but A loses 5 seconds every true hour and reads 10:49, and B gains 7 seconds every true hour and reads 2:01. What is the correct time and how long has it been since the clocks were in agreement? How long will it be before the clocks next read the same and what time will they show?

EDITOR'S NOTE: FOR THE NEXT FOUR MONTHS THIS DEPARTMENT WILL OFFER TWO PROBLEMS ESPECIALLY FOR HIGH SCHOOL STUDENTS. ALL TEACHERS ARE ENCOURAGED TO HAVE THEIR STUDENTS SUBMIT PROBLEMS AND SOLUTIONS FOR THIS SPECIAL SECTION OF THE PROBLEM DEPARTMENT.

STUDENTS SENDING IN SOLUTIONS AND SUBMITTING PROBLEMS FOR SOLUTION SHOULD OBSERVE THE FOLLOWING INSTRUCTIONS:

1. EACH SOLUTION SHOULD BE IN TYPED FORM, DOUBLE SPACED.
2. DRAWINGS IN INDIA INK SHOULD BE ON A SEPARATE PAGE FROM THE SOLUTION.
3. PROBLEMS AND SOLUTIONS SHOULD BE IN THE SAME FORM THAT APPEARS IN THE *JOURNAL*.
4. EACH PROBLEM SHOULD BE ON A SEPARATE SHEET OF PAPER
5. IN GENERAL WHEN SEVERAL SOLUTIONS ARE CORRECT, THE ONE SUBMITTED IN THE BEST FORM WILL BE USED.

STUDENT PROBLEMS FOR SOLUTION

S-1. *Proposed by Lee H. Mitchell, Ann Arbor, Michigan.*

Express all pairs of solutions of the following equations in the simplest form without using mathematical tables.

$$x^2+2xy+3y^2=4$$
$$4x^2+3xy+2y^2=1.$$

S-2. *Proposed by J. W. Lindsey, Amarillo, Texas.*

The base of a triangle is given in magnitude and position and the difference of the squares on the other two sides is also given. Find the locus of the vertex.

Books and Teaching Aids Received

ARITHMETIC, ALGEBRA, LOGARITHMS AND SLIDE RULE WITH PRACTICAL APPLICATIONS, by Robert L. Erickson. Paper. 80 Pages. 15×22.5 cm. 1959. Robert L. Erickson, 2724 Waunona Way, Madison, Wisconsin.

LITERAL NUMBERS, EQUATIONS, FUNCTIONS WITH PRACTICAL APPLICATIONS, AND DIRECT READING TABLES, by Robert L. Erickson. Paper. 130 Pages. 15×22.5 cm. 1957. Robert L. Erickson, Lakeland College, Sheboygan, Wisconsin.

PROPORTIONS, VARIATIONS, PROGRESSIONS, DETERMINANTS, ETC., Volume III, by Robert L. Erickson. Paper. 106 Pages. 15×22.5 cm. 1958. Robert L. Erickson, 2724 Waunona Way, Madison, Wisconsin.

THE NEW AMERICAN GUIDE TO COLLEGES, by Gene R. Hawes. Paper. 256 Pages. 11×18 cm. 1959. New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, New York. Price $.75.

EDUCATION IN THE REPUCLIC OF HAITI, by George A. Dale. Paper. Pages ix+180. 14.5×23 cm. 1959. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $.70.

THE INHABITED UNIVERSE, by Kenneth W. Gatland and Derek D. Dempster. Paper. 206 Pages. 10×18 cm. 1959. Fawcett World Library, 67 West 44th Street, New York 36, New York. Price $.50.

CALCULUS WITH ANALYTIC GEOMETRY, by Donald E. Richmond. Cloth. Pages xv+458. 15×22.5 cm. 1959. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts. Price $8.75.

TAYLOR MEMORIAL MANUAL OF ADVANCED EXPERIMENT IN PHYSICS, by American Association of Physics Teachers. Cloth. Pages xxv+550. 15×23 cm. 1959. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts. Price $9.50.

THE CHEMICAL INDUSTRY FACTS BOOK, 1960–61. Paper. Pages x+163. 15×23 cm. 1959. Manufacturing Chemists' Association, Inc., 1825 Connecticut Avenue, N.W., Washington 9, D. C. Price $1.25.

TEACHER'S GUIDE, for Use With the 1960–61 Edition The Chemical Industry Facts Book. Paper. 31 Pages. 15×22.5 cm. Manufacturing Chemists' Association, Inc., 1825 Connecticut Avenue, N.W., Washington 9, D. C.

SCIENCE FOR CHILDREN, by Muriel Mandell. Cloth. 96 pages. 16×21 cm. 1959. Sterling Publishing Co., Inc., 419 Ave., New York 16, N. Y. Price. $2.50.

AIRCRAFT AND MISSILES, by Dennis M. De Soutter. Cloth. Pages vii+213. 22×28 cm. 1959. John De Graff, Inc., 31 E. 10th St., New York 3, N. Y. Price, $7.50.

CHARLES STEINMETZ, by Henry Thomas. Cloth. 126 pages. 13.5×20.5 cm. 1960. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. Price $2.50.

MAGNETISM AND ELECTROMAGNETISM, by Alexander Schure (Ed.). Paper. Pages vi+71. 14×21.5 cm. 1959. John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y. Price $1.80.

DICTIONARY OF ATOMIC TERMINOLOGY, by Lore Lettenmeyer. Cloth. 298 Pages. 13.5×21 cm. 1959. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $6.00.

UNDERSTANDING CHEMISTRY, by Lawrence P. Lessing. Cloth. Pages vi+192. 14×21 cm. 1959. Interscience Publishers, Inc., 250 5th Ave., New York 1, N. Y.

GERMAN SECRET WEAPONS OF WORLD WAR 2, by Rudolf Lusar. Cloth. Pages xiv+264. 13.5×21.5 cm. 1959. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $10.00.

MODERN HIGH SCHOOL PHYSICS, A Recommended Course of Study, 2ndEdition, by Members of the Science Manpower Project. Paper. Pages viii+70. 14×21 cm. 1959. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. Price. $1.50.

EARTH SCIENCE, The World We Live In, Second Edition, by Samuel N. Namowitz and Donald B. Stone. Cloth. Pages x+614. 17×24 cm. 1960. D. Van Nostrand Co., Inc., Princeton, N. J. Price $5.20.

TEACHING SCIENCE IN TODAY'S SECONDARY SCHOOLS, by Walter A. Thurber and Alfred T. Collette. Cloth. Pages xiv+640. 15×23 cm. 1959. Allyn and Bacon Co., 150 Tremont St., Boston, Mass.

COMPARATIVE ANATOMY OF THE VERTEBRATES, Second Edition, by Theodore H. Eaton, Jr. Cloth. Pages viii+384. 15.5×23.5 cm. 1960. Harper and Brothers, 49 E. 33rd St., New York 16, N. Y. Price $6.00.

RADIATION COUNTERS AND DETECTORS, by C. C. H. Washtell. Cloth. Pages xii+115. 14×21.5 cm. 1960. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $7.50.

The following free teaching aids may be obtained from: Union Springs Central School, Union Springs, N. Y.

THE PROJECT METHOD IN TEACHING. Some comments on this important technique in the teaching of science which includes the set-up of a non-credit or credit science honors course, plus the suggested tools for a lab "shop."

A VISIT TO THE LIBRARY. This contains a brief outline for a student about to undertake library science research, in his every day work or special project work.

STUDY TECHNIQUES. This sheet reviews some of the techniques and tools for efficient study habits.

A BASIC STUDY UNIT IN NUCLEAR SCIENCE. This outline is used in grade 9–12. In grade 9, some of the material can be skipped and in grade 12 some should be expanded, but it is a logical outline for the development of this most important topic.

A BASIC STUDY UNIT IN SPACE will be ready by December 1, 1959.

Book Reviews

THE CANTERBURY PUZZLES, by H. E. Dudeney. Paper. 255 Pages. 13.5×20.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.25.

AMUSEMENTS IN MATHEMATICS, by H. E. Dudeney. Paper. Pages vii+258. 1958. 13.5×20.5 cm. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.25.

MATHEMATICAL PUZZLES OF SAM LOYD. Selected and Edited by Martin Gardner. Paper. Pages xv+167. 13.5×20.5 cm. 1959. Dover Publications, Inc., 180 Varick Street, New York 14, N. Y. Price $1.00.

Many teachers of mathematics have wished they could find available, either for their personal collection, or for the school library, an inexpensive set of mathematical puzzles, tricks, or the like. The three books under consideration seem to fill this need to an unusually high degree. Dudeney was a famous British puzzlemaker. Gardner has collected a very well selected set of mathematical puzzles credited to Sam Loyd. Some of the older generation will recall when Sam Loyd's puzzles were a popular feature in certain periodicals. This particular collection has the additional advantage of classification of puzzles according to the type of mathematics needed for solution. The same is true with respect to Dudeney's *Amusements in Mathematics*.

The puzzles and problems vary from the quite simple to those that are of a high order of difficulty. Some require more ingenuity than mathematical background. Nevertheless, one or all of these books would be a valuable addition to any library.

CECIL B. READ
University of Wichita

THE MATH ENTERTAINER, by Philip Heafford, *University of Oxford*. Cloth. 176 Pages. 12.5×18.5 cm. 1959. Emerson Books, Inc., 251 West 19th Street, New York, N. Y. Price $2.95.

This little book contains fifty puzzles, each containing from four to ten questions. In the opinion of the reviewer they range from the trivial to some having considerable interest. Some sixty pages is given to the quizzes and about twice as much space to the answers. The material is largely of a nature to entertain the reader. It might form some suggested material for certain mathematics club programs. There is some material on the history of mathematics, one quiz involves a statistical graph, one involves calculus. A few of the items might offer some suggestion to the person interested in constructing a test.

In the opinion of this reviewer there are other books available which offer a wider range of material and are of perhaps more significance—certainly of greater value to the library.

CECIL B. READ
University of Wichita

BASIC CONCEPTS IN CHEMISTRY, by George W. Watt, *The University of Texas*. Cloth. Pages ix+538. 15×23 cm. 1958. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N. Y. Price $6.50.

In the preface the author of this textbook of general chemistry states: "It is my sincere hope that this volume reflects a point of view that is certainly not novel among teachers but that has failed to find proper expression in textbooks. This is the conviction that as teachers of college chemistry at the elementary level, we have for many years attempted to teach *too much too early*. Accordingly, this book is dedicated to the idea that it is better to teach thoroughly a limited subject matter field than to overwhelm the student with a body of concepts and factual material that all too often makes for confusion rather than instruction." It is true that in the past twenty years many facts have been added to that body of knowledge called "chemistry." Hence, we are faced with a problem of limiting the subject matter of the elementary course. I feel the author has done this very well by building this textbook around the idea of "basic concepts." He has produced a 538 page book as compared to the usual 700 plus page book of other authors of general chemistry. The reviewer feels confident that the really important facts and principles that are basic to a more advanced study of chemistry are included.

The approach is thoroughly modern and is built around the periodic table with emphasis on ionization potentials, atomic and ionic radii, sub-orbital arrangement of the electrons with energy levels and relative electronegativity. One whole chapter is devoted to the covalent bond. In fact, the first ten chapters deal mainly with basic ideas and principles. The eighth chapter deals fairly completely with the subject of chemical arithmetic. Some college teachers prefer to use the mole method in solving problems based on the balanced equation; however, the author uses the common method found in high school textbooks.

The publishers have done an excellent job; both the paper and the print are superior. The book is well illustrated from the diagram standpoint; however, the reviewer feels that a few pictures of industrial plants would help to give a more realistic approach. For example, when discussing fractional distillation of petroleum on pages 420–423, a picture of a modern petroleum refinery showing the tall fractionating columns would be valuable. At the end of the chapters are found general exercises, problems, and quite often suggested collateral reading.

The reviewer is convinced that a superior freshman chemistry course could be developed around this textbook. Some teachers who wish to spend a 4–6 week period during the second semester on an introduction to organic chemistry would not like the way the organic chemistry is scattered throughout the text.

GERALD OSBORN
Western Michigan University

WOODS HOLE GETS RESEARCH SHIP FROM SCIENCE FOUNDATION GRANT

A $3,000,000 National Science Foundation grant will enable the Woods Hole Oceanographic Institution to construct a 175-foot research vessel.

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Preliminary design of the new ship shows that it will make possible effective oceanographic research in the North and South Atlantic, where most Woods Hole investigations are carried on. She will have a range of 7,500 miles at cruising speeds of 12 knots, and have a loaded displacement of 1,040 tons.

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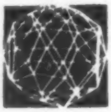

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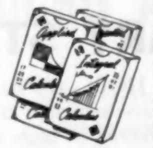

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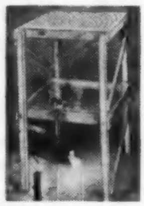

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